Endangered Species Act - Section 7
Consultation

BIOLOGICAL OPINION

Reinitiation of Consultation on 1994-1998
Operation of the Federal Columbia River
Power System and Juvenile Transportation
Program in 1995 and Future Years

Agencies: U.S. Army Corps of Engineers
Bonneville Power Administration
Bureau of Reclamation
National Marine Fisheries Service

Consultation Conducted By: National Marine Fisheries Service, Northwest Region

Date Issued: ________________

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I. INTRODUCTION

A. Background

1. Factual Context

The National Marine Fisheries Service (NMFS) herein provides its recommendations, with this biological opinion and its contemporaneous Proposed Snake River Salmon Recovery Plan[1], constituting a substantial step in a coordinated effort on behalf of the federal government to halt and reverse the declines of endangered Snake River salmon stocks and other declining Pacific salmon stocks.[2] While prepared in response to a reinitiation of consultation for the Federal Columbia River Power System (FCRPS), and the order of U.S. District Court for the District of Oregon[3], this Biological Opinion is first and foremost, a commitment of the federal government to take those steps necessary to implement an ecosystem management approach to improving the likelihood of recovery of the listed species. NMFS is cognizant of the importance of the Pacific Salmon to the history of the Pacific Northwest and to its future. This Biological Opinion, in combination with others and the Proposed Recovery Plan, will establish those measures necessary for the survival and recovery of the listed species, for the benefit of the Northwest Region and the Nation as a whole.

NMFS, throughout the Proposed Recovery Plan and this Biological Opinion, has taken special consideration of its role in the federal government’s fulfillment of the trust relationship with the sovereign governments of the Columbia River Indian tribes.

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[1] Proposed Recovery Plan for Snake River Sockeye Salmon, Snake River Spring/Summer Chinook Salmon, and Snake River Fall Chinook Salmon, U.S. Department of Commerce, National Oceanic Atmospheric Administration, NMFS, to be released for public comment in March 1995 (hereinafter referred to as "Proposed Recovery Plan").

[2] Memorandum of Agreement on Pacific Salmon Conservation White House Office on Environmental Policy, Department of commerce, Department of the Interior, Department of the Interior, Department of the Army, Department of Energy, Department of Agriculture, and the Environmental Protection Agency, October 19, 1994.

[3] Idaho Department of Fish and Game v. National Marine fisheries Service, No. 93-1420-MA, (March 28, 1994) (hereinafter IDFG v. NMFS).

NMFS recognizes the preferred position of Indian treaty fishing. The Proposed Recovery Plan will address all sources of salmon mortality and will include measures to rebuild the stocks so as to meet both the requirements of the ESA and the federal government's treaty obligations and trust responsibilities to the Indian people, including the opportunity to maximize their salmon harvests whenever that is consistent with the overall path to recovery.

Large amounts of time, money and labor have been invested in protecting and rebuilding Columbia River basin salmon and steelhead runs, and still the runs have continued to decline. In the Pacific Northwest, development has often proceeded with the assumption that improved technology or management would mitigate impacts on natural salmon stocks. Unfortunately, the conservation efforts arising from this mitigative approach often do not share common objectives and do not ensure the conservation of natural systems. Regional and state plans present an assortment of measures, some of which actually conflict with one another. It is necessary, now, to establish ecosystem management in the Columbia River Basin.

The unique life-cycle of the listed Snake River Salmon makes them singularly vulnerable to a wide variety of human activities. Salmon may range thousands of miles during a four or five year life cycle, disregarding federal, state, tribal and international management regimes. The enormous range of the Snake River salmon's habitat, from high mountain streams 900 miles inland to Atka Islands of the North Pacific Ocean, and number of competing user groups make the protection and allocation of the salmon resource near impossible.[4] There are individual salmon mortalities at each life stage as a result of a variety of different human activities and natural conditions. In addition to natural mortality, the level of salmon mortality in the egg-to-smolt life stage is affected by various land management activities including logging, livestock grazing and mining. Mortality levels in the juvenile migrant stage are affected by the FCRPS. These juvenile migrants must also compete for food and shelter with hatchery salmon released into the same river habitat. In many cases, hatchery fish attract predators, carry disease and adversely affect the genetic pool of Snake River wild fish.[5] Similarly, while in the ocean, these salmon are subject a myriad of adverse natural and human-caused factors, including

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[4] 56 Fed. Reg. 29542 - 29545 June 27, 1991)(NMFS' Proposed Rule Listing Spring/Summer Chinook Salmon as Threatened Species); 59 Fed. Reg. 42530 (August 18, 1994); Proposed Recover Plan, II. See also, Wilkinson and Conner, supra, 18-21.

[5] 56 Fed. Reg. 29545 (June 27, 1991).

fishing, that contribute to their mortality. Finally, on their return to their upstream spawning habitats, they are again subject to mortality caused, in part, by the hydroelectric system.[6]

The Snake River Basin encompasses 107,000 square miles in the states of Idaho, Oregon, Wyoming and Washington. Historically, spring/summer chinook spawned in virtually all accessible and suitable habitat in the Snake River upstream from its confluence with the Columbia River, as far as Auger Falls, Idaho, 930 miles from the sea. Fall chinook were widely distributed in the mainstem of the Snake River and the lower reaches of its major tributaries, and ranged upstream as far as Shoshone Falls, Idaho. The primary spawning grounds of the fall chinook were the upper reaches of the mainstem Snake River. Snake River sockeye were historically found in the five lakes of the Stanley Basin, Big Payette Lake on the North Fork of the Payette River in Idaho and Wallowa Lake at the headwaters of the Grande Ronde River.[7]

The annual production of Snake River spring/summer chinook during the late 1880's was probably in excess of 1.5 million fish, or 39% to 45% of all Columbia River spring/summer chinook.[8] As the fishery began to decline at the turn of the century, the effects of the exploitation of the salmon's freshwater habitat began to be seen. Timber harvest was typically accomplished by clearcutting and contributed silt to the previously clear gravel bedded streams. Pulp and paper mills processing timber polluted the rivers and streams with byproduct and chemical waste. In the semi-arid reaches of the salmon's range, irrigation dams blocked passage of migrating fish and water withdrawals dried the stream beds altogether. By 1938 the annual anadromous fish catch (no longer measurable in the taking of the prized chinook alone) in the Columbia River had dropped to 18.8 million pounds. Nearly

[6] Id.

[7] Proposed Recovery Plan, Chapter II.

[8] 56 Fed. Reg. 29544 (June 27, 1991) and Proposed Recovery Plan, II-6 - II-9. See also, A. Netboy, supra, 269-283. In 1883, after the establishment of white settlers and the industrialization of the salmon fishery by canning factories, the chinook catch alone was 43 million pounds (of approximately 2.5 to 3.0 million fish). At the end of the nineteenth century the fish wheel was invented and deployed in the Columbia with the capacity to harvest between 200,00 to 400,000 pounds of salmon per wheel per year. The peak of salmon production was achieved from 1880 - 1885 and the trend has been downward ever since.

95% in the total reduction in estimated historic abundance occurred prior to the mid-1900s. During the last 30-40 years the remaining population has been reduced an additional ten fold.[9]

Today, the population of Snake River Spring/Summer chinook is approximately 0.5% of its historic abundance. Approximately 1,800 spring/summer chinook return to the Snake River. No estimates are available for fall run Snake River chinook until the early part of the twentieth century. From 1938, when the gates closed at Bonneville dam, to 1950, the returns of Snake River fall chinook fell from approximately 72,000 to 29,000. Today, approximately 350 Snake River Fall chinook return.[10]

Snake River sockeye were likewise abundant in the 1880s where returns to Wallowa Lake were estimated between 24,000 and 30,000 fish. In one year, 75,000 sockeye were harvested in big Payette Lake alone. During the 1950s and 1960s, the returns to Redfish Lake remained at 4,000 fish. Last year, 1 Snake River sockeye returned to Redfish Lake.[11]

While the cumulative impact of overfishing and habitat degradation prior to 1938 was considerable, many writers attribute the straw breaking the salmon's back to hydroelectric power development and later the multipurpose dam projects in the upper reaches of the Columbia River watershed.[12] NMFS has estimated that of the ten million historical losses of salmon and steelhead, eight million, or 80%, is attributable to hydropower development and operation.[13] Further, NMFS estimates the

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[9] 56 Fed. Reg. 29454-29455 (June 27, 1991). See also, A. Netboy, supra, appendix Table 6; Wilkinson and Conner, supra, 35 n. 95.

[10] Proposed Recovery Plan, II-10; 59 Fed. Reg. 42530-31 (August 18, 1994) (NMFS Emergency Interim Rule, Snake River Spring/Summer Chinook Salmon and Snake River Fall Chinook Salmon).

[11] Proposed Recovery Plan, II-7.

[12] U.S. Comptroller General, Impacts and Implications of the pacific Northwest Power Bill, Rep. No. EMD-79-105; Ebel, "Major Passage Problems," Columbia River Salmon and Steelhead 33 (1977); D. Poon & J. Garcia, " A Comparative Analysis of Anadromous Salmonid Stocks and Possible[s] for the Decline", Northwest Power Planning Council 1982, cited in Wilkinson and Conner, supra 35-43.

[13] Factors for a Decline, Supplement to the Notice of Determination of Snake River Spring/Summer Chinook Salmon Under the Endangered Species Act, NMFS, June 1991, p. 8.

cumulative mortality of spring/summer juvenile chinook passing the mainstem hydroelectric projects to be as high as 91%.[14] However, NMFS has determined that "[n]o single or primary factor could be identified as the primary cause for the decline or as the primary source of mortality; but based on the combination of factors affecting the continued existence of the species, NMFS determined that the species were in danger of extinction or likely to become endangered within the foreseeable future."

In carrying out its statutory mandate, NMFS has recognized that the scientific data and analysis available for these listed species is complex and poses questions for which there are currently no complete answers. While the FCRPS affects the listed species in only two of its life stages, NMFS is cognizant that an effect in one life stage may have implications for the species in later life stages. NMFS has sought a more quantitative assessment of mortality and its reduction, to achieve a consistent reduction in salmon mortality at each life stage and thus in each sector of human activity. NMFS' first efforts are documented in the Appendix to the 1992 FCRPS Biological Opinion.

While useful, this effort was not entirely successful in defining a quantitative goal because available scientific data were inadequate. NMFS concluded "that the approach herein described could provide the basis for a quantitative goal provided we had a means to accurately estimate the human-induced mortality under existing conditions and under conditions resulting from proposed FCRPS actions. Further, there is substantial uncertainty in the estimation of these mortality values."[15]

As a result, NMFS has continued a qualitative approach to determining jeopardy. NMFS has continued to work closer to a quantitative approach while recognizing the limitations of the available data. Ideally, scientific information would be sufficiently developed that NMFS could pinpoint and quantify all the human-induced causes of chinook salmon mortality for each life stage, convert that mortality to adult equivalents, and specify the exact reduction in mortality necessary for each action to ensure that the totality of actions does not reduce appreciably the likelihood of the survival and recovery of listed species. Unfortunately, the available scientific information does not provide much certainty in these areas, except that it is clear that substantial reductions in total human-induced mortality are necessary to prevent further decline in the species. However, scientific uncertainty does not diminish the

[14] Id.

[15] 1992 FCRPS Biological Opinion, pp. 14-15.

critical status of the Snake River salmon, nor does it detract from the need to implement measures necessary for survival and recovery without delay.

To assist NMFS in gathering the best and most credible evidence available, the Proposed Recovery Plan requires the appointment of a Salmon Recovery Implementation Team (Team) representing state, tribal and federal policy leaders.[16] The function of the Team will be to ensure effective coordination and communication among all entities having responsibility for implementing and monitoring the recovery measures proposed in this plan.

NMFS believes that unified federal coordination is an essential step in achieving effective regional planning, implementation, evaluation, and accountability. It is necessary that the federal agencies speak with one voice to facilitate coordination with state, tribal and local governments, as well as the public. In addition, NMFS will convene an independent scientific panel to ensure that the best science is used among the various jurisdictions as they implement and address salmon recovery measures. The first request NMFS will make of the Independent Scientific Panel will be to review a list of critical hypotheses used in formulating recovery measures in the Proposed Recovery Plan. It is imperative to NMFS' accountability and credibility that a science-based decision making structure be established and implemented.

A national effort to establish Pacific Salmon recovery as an important federal goal and to ensure a "single federal voice" was initiated by the signing of a Memorandum of Agreement (MOA) by the Secretaries of Commerce, Interior, Army, Energy, and Agriculture, the Administrator of the Environmental Protection Agency and Director of the White House Office of Environmental Policy. The MOA ensures the highest level of commitment to the development of a coordinated federal effort to achieve Pacific Salmon recovery.

[16] Proposed Recovery Plan, III-4 - III-5.

2. Procedural Context

This is an interagency consultation pursuant to Section 7(a)(2) of the Endangered Species Act (ESA) and implementing regulations found at 50 CFR Part 402. At issue is the Federal Columbia River Power System (FCRPS) and the effect of its operation and facilities on three listed species of Snake River salmon. The federal agencies that operate the FCRPS, namely the Bonneville Power Administration (BPA), the U.S. Army Corps of Engineers (COE), and the U.S. Bureau of Reclamation (BOR) (collectively "the action agencies"), have reinitiated a previously concluded consultation with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) considering the 1994 through 1998 operation of the FCRPS. This is NMFS' biological opinion based upon that reinitiated consultation.

The purpose of this introduction is to review the particular circumstances in which NMFS issues this biological opinion. These circumstances include the particulars of the previous consultation, a judicial judgment setting aside the agencies' 1993 FCRPS consultation and the post-judgment discussions among litigants through which much credible and relevant scientific information and methodologies were submitted to the federal agencies. These circumstances also include a significant projected decline in adult Snake River chinook salmon abundance in 1994 and 1995 which is the basis of NMFS' determination to reclassify Snake River spring/summer and fall chinook salmon from threatened to endangered status. Emergency Interim Rule, 59 FR 42529 (August 18, 1994), and proposed rule, 59 FR 66784 (December 28, 1994).

In the previous consultation, NMFS issued a biological opinion concerning an operation for the FCRPS for 1994 through January 31, 1999. <u>Endangered Species Act (ESA) Section 7 Consultation Regarding 1994-1999 Operation of the Federal Columbia River Power System and Juvenile Transportation Program in 1994-1998</u>, issued March 16, 1994, by Rolland A. Schmitten, Assistant Administrator for Fisheries, National Marine Fisheries Service. That opinion considered a plan of actions for the FCRPS that the action agencies proposed on December 2, 1993, in their biological assessment, and in revisions submitted in January, 1994. See <u>Biological Assessment on 1994-1998 Federal Columbia River Power Operations</u>, submitted to the National Marine Fisheries Service by Bonneville Power Administration, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, December 1993, as revised by the letter from W. Pollock (BPA), K. Pedde (BOR) and D. Geiger (COE) to G. Smith (NMFS), dated January 31, 1994.

That March 16, 1994, biological opinion and the action agencies' records of decision concluded that the proposed operation of the FCRPS was not likely to jeopardize the continued existence of the endangered or then threatened Snake River salmon species. The opinion included an incidental take statement pursuant to Section 7(a)(4) of the ESA which required that the action agencies comply with certain reasonable and prudent measures, terms and conditions intended to further avoid and minimize take of listed salmon.

Contemporaneous with this previous consultation, in federal district court proceedings, the Idaho Department of Fish and Game, the State of Oregon, joined by four treaty Indian tribes, challenged the legal adequacy of NMFS' 1993 FCRPS biological opinion. Idaho Department of Fish and Game v. National Marine Fisheries Service, Civ. No. 92-973-MA (Lead Case), 93-1420-MA, 93-1603-MA, (D. Or.)(hereafter "IDFG v. NMFS"). On March 28, 1994, Federal District Judge Malcolm Marsh issued his judicial opinion that set aside NMFS' biological opinion on the 1993 FCRPS operation, Biological Opinion on 1993 Operation of the Federal Columbia River Power System, National Marine Fisheries Service, May 26, 1993. In a judgment entered on April 28, 1994, the Court ordered at page 4 that:

> IT IS FURTHER ORDERED AND ADJUDGED that the Biological Opinion on 1993 Federal Columbia River Power System operations prepared by the National Marine Fisheries Service, and the Records of Decision prepared by the Corps of Engineers and Bureau of Reclamation in reliance upon said biological opinion, for the reasons stated in this court's opinion of March 28, 1994, are arbitrary and capricious and otherwise not in accordance with the purposes of the Endangered Species Act, Section 7(a)(2), with respect to the chosen jeopardy standard and their consideration of reasonable and prudent alternatives to avoid jeopardy. That the 1993 biological opinion and records of decision are set aside and remanded to federal defendants with instructions to review and reconsider them, or at their option, to review and reconsider the 1994-98 hydropower biological opinion, in light of the the (sic) court's order of March 28, 1994, and to submit a biological opinion and records of decision to address that ruling by June 27, 1994, unless that date is extended by further order of this court.

The NMFS and the action agencies, the defendants in this lawsuit, opted to reconsider the newly issued 1994-1998 FCRPS biological opinion rather than expend limited resources reconsidering the challenged 1993 opinion about FCRPS actions that were then completed. Letter from Fred R. Disheroon, Esq., U.S. Department of Justice, to U.S. District Judge Malcolm Marsh dated April 7, 1994. The federal agencies further decided to work cooperatively with all of the other parties, and particularly with the sovereign States and treaty Indian tribes, rather than appealing the Judgment and continuing to litigate the issues raised in the case. FEDERAL DEFENDANTS' REPORT ON COMPLIANCE WITH THE JUDGEMENT, filed in IDFG v. NMFS, dated June 28, 1994.

From May 9, 1994, through November 30, 1994, NMFS and the action agencies participated in a series of discussions and working groups with the parties to this litigation. The purpose of these discussions has been to better facilitate the collection and consideration of credible and relevant scientific evidence in a re-evaluation of the application of the standards of ESA § 7(a)(2) to the FCRPS and of alternatives and measures for FCRPS operation and facilities. The federal agencies and other parties to the litigation have been aided by technical assistance provided through interagency working groups of technical personnel; one to consider the biological requirements of the listed species and the other to inventory and evaluate alternative actions and measures for the FCRPS.

The Court extended the original deadline established by the Judgement directing the issuance of a new biological opinion by January 30, 1995. IDFG v. NMFS, Civil Minutes, Record of Order dated October 18, 1994: Granting Federal defendants October 8, 1994, request for extension of time as set forth in the schedule attached to William Stelle, Jr.'s affidavit. The Court granted further extensions in this deadline until to March 1, 1995.

With the conclusion of these post-judgment discussions this consultation was formally reinitiated by the action agencies on December 15, 1994. Letter from Major General Ernest J. Harrell (COE) to William W. Stelle, Jr. (NMFS) and Michael Spear (USFWS), dated December 15, 1994, transmitting the Supplemental Biological Assessment on Federal Columbia River Power Operations on behalf of the U.S. Army Corps of Engineers, the Bonneville Power Administration and the Bureau of Reclamation. This letter identifies the proposed action as the 1994-1998 proposed operations of the previous consultation while at the same time the supplemental biological assessment submits for consideration longer-term changes in operations and structures such as those identified in their System Operations Review Environmental Impact Statement and System Configuration Study.

This biological opinion has been coordinated with the U.S. Fish and Wildlife Service (USFWS). The USFWS and NMFS will prepare separate biological opinions concerning the effects of the operation of the FCRPS upon listed species within its jurisdiction.

The NMFS finds, as documented in this biological opinion, that there is sufficient new scientific information and methodology that has been obtained since the agencies concluded the previous consultation on March 16, 1994, to warrant this reinitiated consultation. Furthermore, it is appropriate for NMFS to reevaluate the totality of available information to address the concerns raised by the Court in the IDFG v. NMFS opinion of March 28, 1994.

B. Application of ESA Standards to Federal Actions

The NMFS evaluates the effects of proposed federal actions on the listed Snake River salmon in this and every section 7 consultation by applying the standards of § 7(a)(2) of the ESA, 16 U.S.C § 1536(a)(2), as interpreted by the NMFS/Fish and Wildlife Service (FWS) joint consultation regulations (50 CFR Part 402). The discretionary continuation of an action is also a proposed action in this context. Using the best scientific and commercial data available, when NMFS issues its biological opinion, it determines whether a proposed Federal action is likely to (1) jeopardize the continued existence of a listed species, or (2) destroy or adversely modify the designated critical habitat of a listed species. See ESA § 7(a)(2).

The consultation regulations define "jeopardize the continued existence of" to mean:

> ...to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 C.F.R. § 402.02).

The regulations also define the statutory term "destruction or adverse modification" of critical habitat to mean:

> . . . a direct or indirect alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species. Such alterations include, but are not limited to, alterations adversely modifying any of those physical or biological features that were the basis for determining the habitat to be critical. (50 C.F.R. § 402.02)

Additionally, NMFS and FWS have recently issued, for public comment, a document that further describes the application of these standards entitled "Draft Section 7 Endangered Species Consultation Handbook -- Procedures for Conducting Section 7 Consultations and Conferences", 59 Federal Register 65781 (December 21, 1994)(hereafter "the Draft Handbook").

The regulatory terms "survival" and "recovery" are defined by the Draft Handbook for use in the jeopardy/critical habitat analysis as follows:

> **Survival**: the species' persistence, beyond conditions leading to its endangerment, with sufficient resilience to allow recovery. Said another way, survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficiently large population, represented by all age classes, genetic heterogeneity, and a number of sexually mature individuals producing viable offspring, that exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter.
>
> **Recovery:** improvement in the status of a species and the ecosystems upon which they depend. Said another way, recovery is the process by which species' ecosystems are restored so they it can support self-sustaining and self-regulating populations of listed species as persistent members of native biotic communities.

In implementing these standards for Pacific salmon species, NMFS recognizes certain characteristics of Pacific salmon species that require special consideration. The Columbia River Basin, in which the Snake River salmon originate, drains a vast area of the Pacific Northwest; approximately 259,000 square miles in size, the Basin is located in the states of Washington, Oregon, Idaho, and Montana, as well as British Columbia. The life cycle of these listed fish begins in small mountain streams, lakes and rivers (depending on the species) of the Snake River system in Idaho and eastern Oregon and Washington where eggs are deposited and fertilized by spawning adults, incubate within gravel substrates, hatch and subsequently emerge to rear before they begin, as yearlings or subyearlings, their migration down the mainstems of the Snake and Columbia River systems to the Pacific Ocean. There they range from the mouth of the Columbia in all directions; to the north they range at least as far as ocean waters off of Alaska. The listed species grow to adult size in the ocean and then complete their life-cycle by reversing their migration from the ocean, up the Columbia and Snake Rivers to return to their natal habitat to spawn for the next generation.

In each consultation concerning these Snake River salmon, NMFS follows the following analysis to apply these ESA standards to these unique characteristics of salmon:

1. Define the biological requirements of the listed species.

To determine whether a proposed or continuing action is likely to jeopardize the continued existence of listed species or adversely modify its habitat, it is first necessary to know what is required for the species’ continued existence, which is more specifically expressed by the regulations in terms of the species’ survival and recovery. The biological requirements of Snake River salmon may be described in a number of different ways. For example, they can be expressed as a ratio of recruits to spawners, as a survival rate for a given life stage or set of life stages, as a positive population trend line, or as a threshold population size. Biological requirements may also be described as the environmental conditions necessary to ensure the species’ continued existence, expressed in terms of physical, chemical, and biological prerequisites (e.g., for a particular river reach, the prerequisite would include water temperature, velocity, dissolved gas saturation, etc.). The manner in which these requirements are described varies according to the nature of the action under consultation and its likely effects on the species. For example, the consultation on the FCRPS is primarily in terms of individual salmon mortalities whereas a consultation on an action in spawning and rearing habitat may be defined more by changes in environmental conditions.

2. Evaluate the relevance of the environmental baseline to the species’ current status.

The environmental baseline, to which the effects of the proposed or continuing action would be added, "includes the past and present impacts of all Federal, State, or private activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process." See 50 C.F.R. § 402.02, definition for "effects of the action".

Consistent with this definition, the environmental baseline does not include future discretionary activities within the action area that have not undergone ESA consultation. Thus the current status of the species is described in relation to the risks presented by the continuing effects of all previous actions and resource commitments that are not subject to further exercise of federal discretion. For a new project, the environmental baseline represents the risks to the species of the pre-project action area. For an ongoing federal action, it is necessary to evaluate the effects of previous resource commitments separately from the effects that would be caused by that action's future prosecution as proposed.

An initial consideration in identifying the environmental baseline is to delineate the "action area" for the proposed or continuing action. It is the environmental baseline of the action area that the regulations specify for use in the jeopardy determination. The "action area" is defined by the consultation regulations as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." 50 CFR §402.02.

The purpose of considering status of the species under the risks presented by the environmental baseline without the proposed or continuing action is to better understand the relative significance of the action's effects upon the species' likelihoods of survival and recovery when those effects are added to the environmental baseline. The greater the risks faced by the species at the time of consultation the more significant are any additional adverse effects to the listed species caused by the proposed or continuing action.

3. Determine the effects of the proposed or continuing action on listed species.

In this step of the analysis, NMFS examines the likely effects of the proposed agency action on the species. The analysis may consider the impact in terms of mortalities inflicted during a particular life stage and that mortality's effect upon the species' population size and variability, or the analysis may consider the impact on species needs, such as water temperature, sediment load, total dissolved gas levels, etc. These are the effects that are, or with further authorizations and appropriations could be, within the action agencies' discretion to impose or not, a decision that is influenced by NMFS advice in this biological opinion.

4. Determine whether the species can be expected to survive with an adequate potential for recovery under the effects of the proposed or continuing action, the environmental baseline and any cumulative effects, and considering measures for survival and recovery specific to other life stages.

In this step of the analysis, NMFS determines whether the specific action under consultation is likely to jeopardize the continued existence of the listed species. This step has two parts for Pacific salmon species. The NMFS must first focus on the action area and add up the effects of the proposed or continuing action, together with those of the environmental baseline and all cumulative effects. The NMFS must determine the significance of that aggregate effect upon the particular biological requirements of the listed species in that action area. At this point, NMFS considers effects such as, for example, the frequency of mortality to individual members of the species, or any sublethal effects, caused directly by the action or through the action's adverse modification of environmental conditions important to the species.

The second part of the analysis calls for NMFS to place the effects of the proposed or continuing action in the context of the full salmon life cycle. This comprehensive analysis is necessary to fully evaluate the significance of each action under consultation to the biological requirements of the listed species in all life stages. The NMFS looks beyond the particular action area for this analysis to consider measures likely to be necessary in all life stages that, in combination, would insure that the biological requirements of the listed species will be met and thereby insure its continued existence.

At the species level, NMFS considers that the biological requirements for survival, with an adequate potential for recovery, are met when there is a high likelihood that the species' population will remain above critical escapement thresholds over a sufficiently long period of time. Additionally, the species must have a moderate to high likelihood that its population will achieve its recovery level within an adequate period of time. The particular thresholds, recovery levels and time periods must be selected depending upon the characteristics and circumstances of each salmon species under consultation.

Recovery plans for listed salmon call for measures in each life stage that are based upon the best available scientific information concerning the listed species' biological requirements for survival and recovery. As the statutory goal of the recovery plan is for the species' conservation and survival it necessarily must add these life-stage specific measures together to result in the survival of the species, at least, and in its recovery and delisting at most. For this reason, the Recovery Plan is the best source for measures and requirements necessary in each life stage to meet the biological requirements of the species across its life cycle.

In circumstances faced by these listed Snake River salmon, where their current status, as affected by environmental baseline, is such that there is a low expectation of survival with an adequate potential for recovery, the proposed or continuing actions must reduce risks to the listed species in the action area to insure that the likelihood of the species' survival and recovery is not appreciably reduced. The amount of risk reduction necessary to determine that the action will not likely jeopardize the listed species will depend upon the current status of the species. Again, the Recovery Plan will be the best evidence of the amount of improvement required in each life stage and the measures likely to accomplish that reduction sufficient to satisfy the requirements of Section 7(a)(2). **NMFS will therefore first consider whether the proposed action is consistent with the Recovery Plan. If not, NMFS will consider whether the proposed action reduces the risks to the listed species as much as or more than the Recovery Plan.**

5. Identify reasonable and prudent alternatives to a proposed or continuing action that is likely to jeopardize the continued existence of the listed species.

If the proposed or continuing action is likely to jeopardize the listed species, NMFS must consider potential reasonable and prudent alternatives that would comply with ESA Sec. 7(a)(2). In that case, the Snake River Salmon Recovery Plan, the current draft of which lays out measures "for the conservation and survival of endangered species", ESA § 4(f), is the best source of reasonable and prudent alternatives that the action agency may implement and thereby meet its obligations under ESA § 7(a)(2).

II. PROPOSED ACTION

The proposed action in this reinitiated consultation is the continuing operation of the Federal Columbia River Power System in 1995 and future years. The action considered by this biological opinion is described in Section II.A-II.G of the biological opinion regarding <u>1994-1998 Operation of the FCRPS and Juvenile Transportation Program in 1994-1998</u> (March 16, 1994) and that opinion's Incidental Take Statement (Section XI).

The action agencies identified the action for NMFS' consideration in this reinitiated consultation to be the FCRPS operations proposed for and resulting from the previous consultation while at the same time submitting for NMFS' consideration, in the event the proposed action was not likely to satisfy ESA standards, intermediate and long-term changes in operations and structures such as those identified in their System Operations Review Environmental Impact Statement and System Configuration Study. See the letter of Major General Ernest J. Harrell (COE) to William W. Stelle, Jr. (NMFS) and Michael Spear (USFWS), dated December 15, 1994, transmitting the <u>Supplemental Biological Assessment on Federal Columbia River Power Operations</u>.

Therefore, NMFS finds that the scope of this consultation, upon reinitiation, is longer than the initial five-year scope of the original consultation and includes consideration of measures in the intermediate and long term. For the purposes of considering whether the proposed action jeopardizes the listed species, NMFS interprets the action agencies' proposal to be the previously described FCRPS operations to be continued in 1995 and future years, though not necessarily limited to the five year time frame as was originally proposed.

III. LISTED SPECIES AND CRITICAL HABITAT

The three Snake River salmon populations listed as endangered under the ESA occur within the FCRPS action area addressed in this Opinion. Snake River sockeye salmon (*Oncorhynchus nerka*) were listed as endangered (November 20, 1991, 56 FR 58619). Snake River spring/summer chinook salmon (*O. tshawytscha*) and Snake River fall chinook salmon (*O. tshawytscha*) were originally listed as threatened (April 22, 1992, 57 FR 14653), but are proposed for reclassification as endangered (interim emergency rule, August 18, 1994, 59 FR 42529 and proposed rule, December 28, 1994, 59 FR 66784).

Critical habitat was designated for Snake River sockeye salmon, Snake River spring/summer chinook salmon, and Snake River fall chinook salmon on December 28, 1993 (58 FR 68543), effective on January 27, 1994. The designation of critical habitat provides notice to Federal agencies and the public that these areas and features are vital to the conservation of listed Snake River salmon.

Essential Snake River salmon habitat consists of four components: (1) Spawning and juvenile rearing areas, (2) juvenile migration corridors, (3) areas for growth and development to adulthood, and (4) adult migration corridors. Essential features of the juvenile and adult migration corridors for Snake River sockeye salmon, Snake River spring/summer chinook salmon, and Snake River fall chinook salmon include adequate: (1) Substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover and shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions. Food is an additional essential habitat feature for juveniles of all three listed salmon species.

A. Species’ Life Cycle and Historical Population Trends

1. Snake River Sockeye Salmon

Snake River sockeye salmon adults enter the Columbia River primarily during June and July. Arrival at Redfish Lake, which now supports the only remaining run of Snake River sockeye salmon, peaks in August and spawning occurs primarily in October (Bjornn et al. 1968). Eggs hatch in the spring between 80 and 140 days after spawning. Fry remain in the gravel for three to five weeks, emerge in April through May and move immediately into the lake, where juveniles feed on plankton for one to three years before they migrate to the ocean (Bell 1986). Migrants leave

Redfish Lake from late April through May (Bjornn et al. 1968), and smolts migrate almost 900 miles to the Pacific Ocean. For detailed information on the Snake River sockeye salmon, see Waples et al. (1991a) and November 20, 1991, 56 FR 58619.

Passage at Lower Granite Dam (the first dam on the Snake River downstream from the Salmon River) ranges from late April to July, with peak passage from May to late June (Fish Passage Center 1992). Once in the ocean, the smolts remain inshore or within the Columbia River influence during the early summer months. Later, they migrate through the northeast Pacific Ocean (Hart 1973, Hart and Dell 1986). Snake River sockeye salmon usually spend two to three years in the Pacific Ocean and return in their fourth or fifth year of life.

Historically, the largest numbers of Snake River sockeye salmon returned to headwaters of the Payette River, where 75,000 were taken one year by a single fishing operation in Big Payette Lake (Bevan et al. 1994). During the early 1880s, returns of Snake River sockeye salmon to the headwaters of the Grande Ronde River in Oregon (Wallowa Lake) were estimated between 24,000 and 30,000 at a minimum (Cramer 1990, cited in Bevan et al. 1994). During the 1950s and 1960s, adult returns to Redfish Lake numbered more than 4,000 fish (Bevan et al. 1994).

Snake River sockeye salmon returns to Redfish Lake since at least 1985, when the Idaho Department of Fish and Game began operating a temporary weir below the lake, have been extremely small (Table 1). Snake River sockeye salmon have a very limited distribution relative to critical spawning and rearing habitat. Redfish Lake represents only one of the five Stanley Basin lakes historically occupied by Snake River sockeye salmon and designated as critical habitat for the species.

Table 1. Returns of Snake River sockeye salmon to Redfish Lake, as determined by trapping at Redfish Lake creek weir and spawning ground surveys.

Year	Adults Observed
1985	12
1986	29
1987	16
1988	4
1989	1
1990	0
1991	4
1992	1
1993	8
1994	1

2. Snake River Spring/Summer Chinook Salmon

The present range of spawning and rearing habitat for naturally-spawned Snake River spring/summer chinook salmon is primarily limited to the Salmon, Grande Ronde, Imnaha, and Tucannon subbasins. Most Snake River spring/summer chinook salmon enter individual subbasins from May through September. Juvenile Snake River spring/summer chinook salmon emerge from spawning gravels from February through June (Perry and Bjornn 1991). Typically, after rearing in their nursery streams for about one year, smolts begin migrating seaward in April through May (Bugert et al. 1990; Cannamela 1992). After reaching the mouth of the Columbia River, spring/summer chinook salmon probably inhabit nearshore areas before beginning their northeast Pacific Ocean migration, which lasts two to three years. For detailed information on the life history and stock status of Snake River spring/summer chinook salmon, see Matthews and Waples (1991), NMFS (1991a), and 56 FR 29542 (June 27, 1991).

The number of wild adult Snake River spring/summer chinook salmon in the late 1800s was estimated by Bevan et al. (1994) to be more than 1.5 million fish annually. By the 1950s, the population had declined to an estimated 125,000 adults. Escapement estimates indicate that the population continued to decline through the 1970s. Redd count data also show that the populations continued to decline through about 1980. See Table 2 for the estimated annual number of wild adult Snake River spring/summer chinook salmon returning over Lower Granite Dam (escapement) in recent years.

Table 2. Estimates of "wild-natural" Snake River spring/summer chinook salmon counted at Lower Granite Dam in recent years. Estimates through 1993 from Tables 26 and 33 of WDFW and ODFW (1994). Preliminary estimate for 1994 from TAC (1994).

Year	Spring Chinook	Summer Chinook	Total
1985	6048	3196	9244
1986	7925	3934	11,859
1987	8928	2414	11,342
1988	10,915	2263	13,178
1989	3900	2350	6250
1990	4152	3378	7530
1991	2706	2814	5520
1992	8196	1148	9344
1993	6224	3959	10,183
1994	1517	305	1822
Threshold Esc. Level			Approx. 11,000-22,000
Recovery Esc. Level			31,440

The Snake River spring/summer chinook salmon Evolutionarily Significant Unit (ESU), the distinct population segment listed for ESA protection, consists of 39 local spawning populations (subpopulations) spread over a large geographic area (Lichatowich et al. 1993; see Table 3). The number of fish returning to a given subpopulation would therefore be much less than the total run size.

Based on recent trends in redd counts in major tributaries of the Snake River, many subpopulations could be at critically low levels. Subpopulations in the Grande Ronde River, Middle Fork Salmon River, and Upper Salmon River basins are at particularly high risk. Both demographic and genetic risks would be of concern for such subpopulations, and in some cases, habitat may be so sparsely populated that adults have difficulty finding mates.

Table 3. Snake River spring/summer chinook salmon classification by subbasin (metapopulations) and subpopulation. Based on Lichatowich et al. 1993, SRSRT Table VI-1, and BRWG 1994. SP = spring chinook population; SU = summer chinook population

River System/Subbasin	Breeding Unit/Subpopulation
Tucannon River	watershed population (SP)
Grande Ronde River	Minam River (SP)
	Lostine and Upper Wallowa Rivers and tributaries (SP)
	Wenaha River (SP)
	Catherine Creek (SP)
	Upper Grande Ronde (SP)
Imnaha River	mainstem (SP/SU)
	Big Sheep and Lick Creeks
Snake River mainstem	Asotin Creek (SP)
	mainstem, Sheep, Granite Creeks (SP)
Lower Salmon River	mainstem tributaries, mouth to and including Horse Creek (SP)
Little Salmon River	watershed except Rapid River (SP)
	Rapid River (SU)
South Fork Salmon River	mainstem, Blackmare to Stolle Creeks (SU)
	mainstem, mouth to Poverty Flats (SU)
	Secesh River (SU)
	Johnson Creek (SU)
	East Fork South Fork (SU)
Middle Fork Salmon River	mainstem, mouth to Indian Creek (SU)
	mainstem, Indian to Bear Valley Creek (SP)
	Marsh Creek and tributaries (SP)
	Bear Valley and Elk Creeks (SP)
	Sulphur Creek
	Upper Loon Creek and tributaries (SP)
	Lower Loon Creek (below TM 23) (SU)
	Camas Creek (SP)
	Lower Big Creek (below TM 23) (SU)
	Upper Big Creek and tributaries (SP)
Lemhi River	watershed population (SP)
Pahsimeroi River	watershed population (SU)
Upper Salmon River	North Fork Salmon River (SP)
	East Fork, mouth to Herd Creek (SU)
	Herd Creek and Upper East Fork (SP)
	Yankee Fork and tributaries (SP)
	Valley Creek above Stanley Creek (SP)
	Lower Valley Creek (SU)
	mainstem Salmon below Redfish Lake Creek (SU)
	mainstem Salmon above Redfish Lake Creek (SU)
Clearwater River	[not listed under ESA]

3. Snake River Fall Chinook Salmon

Adult Snake River fall chinook salmon enter the Columbia River in July and migrate into the Snake River from August through October. Fall chinook salmon natural spawning is primarily limited to the Snake River below Hells Canyon Dam, and the lower reaches of the Clearwater, Grand Ronde, Imnaha, Salmon, and Tucannon Rivers. Fall chinook salmon generally spawn from October through November and fry emerge from March through April. Downstream migration generally begins within several weeks of emergence (Becker 1970, Allen and Meekin 1973) with juveniles rearing in backwaters and shallow water areas through mid-summer prior to smolting and migration. They will spend one to four years in the Pacific Ocean before beginning their spawning migration. For detailed information on the Snake River fall chinook salmon, see Waples et al. (1991b), NMFS (1991b) and June 27, 1991, 56 FR 29542.

No reliable historic estimates of abundance are available for Snake River fall chinook salmon (Bevan et al. 1994). Estimated returns of Snake River fall chinook salmon declined from 72,000 annually between 1938 and 1949, to 29,000 from 1950 through 1959 (Bjornn and Horner 1980, cited in Bevan et al. 1994). Estimated returns of naturally produced adults from 1985 through 1993 range from 114 to 742 fish (Table 4).

Table 4. Estimates of naturally-produced adults to Lower Granite Dam (not adjusted to include naturally-produced adults trapped at Ice Harbor Dam). Estimates for 1985-1993 are from Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife (1994). Preliminary estimate for 1994 from Loch (1995).

Return Year	Natural Adults
1985	435
1986	449
1987	252
1988	368
1989	295
1990	78
1991	318
1992	549
1993	742
1994	[Natural Count Not Available; Total Count = 852]

Specific projections for returns of fall chinook over the next three to five years (1996-1998) cannot be made, but it is possible to comment generally on the prospects for greater returns. The 1991 brood is weak, based on the record low return of jacks in 1993. There was certainly sufficient escapement in 1992 and 1993 to allow for increased returns after 1995, but higher returns will depend largely on improved passage and ocean survival conditions.

B. Biological Requirements for Listed Snake River Salmon

In this first step of the method, NMFS uses for applying the ESA standards of § 7(a)(2) to these species of salmon, NMFS defines the biological requirements for these species that are most relevant for this consultation. The NMFS (1995a) is a detailed discussion of how NMFS defined these biological requirements of listed Snake River salmon and methods of assessing whether the biological requirements are likely to be met under a given set of actions. What follows here is a summary of NMFS' conclusions, based upon the considerations described in NMFS (1995a). Generally, NMFS finds that these biological requirements are best expressed as population trends, size and variability. Environmental requirements are also relevant and useful for particular aspects of the FCRPS operation as, for example, in the case of dissolved gas levels as a criterion of water quality.

To a large extent, these biological requirements are based upon the work of a Biological Requirements Work Group (BRWG) composed of scientists and fishery managers from the Federal agencies and sovereign parties (States and tribes) that met as a component of the post judgment discussions of the IDFG v. NMFS parties. The NMFS also was guided by scientific opinion provided by the intervenors to this litigation. It is the BRWG report, and NMFS' evaluation of it, that is discussed in detail in NMFS (1995a).

In summary, the approach presented by the BRWG report, and to a large extent followed by NMFS, is a method of determining the listed species' likelihoods of survival and recovery.

The BRWG considered the **likelihood of survival** to be the probability that a set of actions encompassing all phases of the species' life cycle would result in population levels above threshold escapement levels over a short-term period (24 years) and a long-term period (100 years). The BRWG (1994) proposed that this likelihood should be estimated for Snake River spring/summer and fall chinook salmon using regional life-cycle models. For Snake River sockeye salmon, the estimate would be approached in a less complex manner because of low population abundance, lack of passage studies directed at this species, and uncertainties regarding releases from the captive broodstock program.

The BRWG (1994) considered the **likelihood of recovery** to be the probability that a set of actions encompassing all phases of the species' life cycle would result in eight-year (approximately two generations) geometric mean population levels greater than recovery population levels. An expected recovery time period is also necessary to make this determination (i.e., to determine the likelihood of reaching an eight-year mean recovery population level within x number of years from the present). Recovery time periods suggested were 12, 24, and 48 years.

As with the likelihood of survival, the BRWG (1994) proposed that the likelihood of recovery should be estimated for Snake River spring/summer and fall chinook salmon using regional life-cycle models. For Snake River sockeye salmon, the estimate would be approached in a less complex manner for the same reasons cited above.

The NMFS finds this to be a useful approach, among others, as discussed in NMFS (1995a), and thus considers the determination of survival and recovery thresholds as the first step in applying this methodology.

1. Survival Requirements

Each Pacific salmon species is composed of numerous geographically isolated breeding units (stocks). The stock structure of the Pacific salmon is the result of their propensity for returning to their native stream to spawn and their individual adaptations to local environments (Helle 1981).

In small populations, random processes can lead to two major types of risk: demographic and genetic. Demographic risk is the risk of extinction due to environmental fluctuations, random events affecting individuals in the population, and possible reductions in reproduction or survival resulting from low population sizes. Genetic risk is the risk of losing genetic variability or population fitness through inbreeding and genetic drift. Both types of risk increase rapidly as population size decreases.

Severe, short-term genetic problems from inbreeding are unlikely unless population size remains very low for a number of years. However, the erosion of genetic variability due to low population size is cumulative; thus, long-term effects on a population (even if it subsequently recovers numerically) are also a concern.

The BRWG and NMFS considered these factors in defining potential numerical population thresholds of returning spawners for use in defining biological requirements for particular salmon stocks. The threshold levels recommended by the BRWG, and adopted by NMFS, do not represent levels at which the trend toward extinction is expected to be irreversible. The BRWG’s suggested threshold escapement levels and suggested methods of analysis indicate that populations will be able to fall below these levels periodically and recover to higher levels, even when biological processes particular to low population levels is taken into account. This interpretation is consistent with the observation that the proposed levels are substantially higher than any directly identifiable risk levels such as genetic or demographic bottlenecks.

These threshold population levels for survival correspond to the definition of "survival" found in NMFS’ and FWS’ "Draft Section 7 Endangered Species Consultation Handbook--Procedures for Conducting Section 7 Consultations and Conferences". That term requires "sufficiently large populations" to ensure persistence into the future under conditions that will retain the potential for recovery. In an independent peer review of the BRWG report, Barnthouse et al. (1994) concluded that the BRWG’s method of developing threshold levels was credible.

(a). Snake River Spring/Summer Chinook Salmon

The primary threshold level recommended by the BRWG was 150 natural spawners annually (for small, concentrated subpopulations of Snake River spring/summer chinook salmon) or 300 natural spawners annually (for larger, dispersed Snake River spring/summer chinook salmon subpopulations and Snake River fall chinook salmon).

The NMFS adopts the BRWG-recommended threshold level of 150-300 spawners annually per subpopulation, depending upon size of the subpopulation, for purposes of the jeopardy analysis applicable to Snake River spring/summer chinook salmon. Threshold levels associated with the six subpopulations currently available for analysis are presented in Table 5.

Based on consideration of factors described in NMFS (1995a), NMFS concludes that the best available method of characterizing risk to the ESU is to use projections based on available subpopulations. Because the few available subpopulations do not represent conditions within the entire ESU, it is prudent to require that a high percentage of available subpopulations have an acceptable probability of being above the threshold level. A "high percentage" is defined as at least 80% of available "index stocks".

The NMFS encourages development of techniques that will allow incorporation of additional subpopulations into future analyses, as suggested in BRWG (1994) and Barnthouse et al. (1994a). The NMFS also encourages analysis of ancillary information, such as aggregate assessments based on dam counts, to supplement the subpopulation analyses. If assessments based on dam counts support conclusions based on subpopulations, NMFS will have greater confidence in reaching those conclusions. If the two analyses lead to different conclusions, it will be a signal to carefully review the subpopulation assessments; however, as stated above, the final determination will be based upon the subpopulation analyses.

The BRWG did not identify a threshold level for the entire Snake River spring/summer chinook ESU that could be used for comparative purposes for aggregate projections based on dam counts. It is reasonable to assume that, because the ESU is composed of approximately 39 subpopulations with thresholds ranging from 150-300 spawners annually, the aggregate threshold is between 6000-12,000 spawners annually. This estimate assumes that spawners are distributed among all subpopulations in proportion to each subpopulation’s threshold. If this assumption is not valid, the aggregate threshold would be higher than 6000-12,000 spawners annually.

Snake River spring/summer chinook salmon returns to six subbasins suggested by the BRWG (1994) as index stocks for assessing status of the ESU have generally been below threshold escapement levels since 1989 (Table 5). Cohort replacement rates (= spawner-to-spawner ratios) have been less than 1.0 (i.e., the population has been declining) for most of these stocks during recent years (Table 6). A threshold escapement level for the entire spring/summer chinook ESU was not suggested by BRWG (1994), but presumably would be between approximately 6000-12,000 spawners for an aggregation of the 39 subpopulations identified by BRWG (1994). Assuming a mortality between Lower Granite Dam and the spawning ground of approximately 40-60% (midpoint 50%) for the spring component and 30-40% (midpoint 35%) for the summer component of the ESU (Chapman et al. 1991) and an average ratio of 65% spring component during the past 10 years (Table 2), the corresponding escapement at Lower Granite Dam would be approximately 11,000-22,000 natural spawners. Adult counts at Lower Granite Dam have generally been below this level in recent years (Table 2).

Table 5. Estimated spawner counts for five subpopulations of Snake River spring/summer chinook salmon during recent years. Reproduced from Table 3.1 of BRWG (1994). Estimates through 1993 from Idaho Dept. of Fish and Game and Oregon Dept. of Fish and Wildlife, expanded from redd counts in index areas. Bold values represent estimates that meet or exceed threshold escapement levels recommended by BRWG (1994). Recovery escapement levels based on 60% of pre-1970 average escapements.

Year	Bear Valley/ Elk Creeks	Imnaha River	Marsh Creek	Minam River	Poverty Flats of S. Fork Salmon River	Sulphur Creek
1985	295	**783**	**197**	**479**	**342**	70
1986	235	**1159**	**184**	130	246	**458**
1987	**457**	**535**	**273**	**222**	**508**	77
1988	**1116**	**719**	**395**	**224**	**763**	**289**
1989	91	**439**	80	136	258	14
1990	189	272	104	95	**513**	**155**
1991	184	209	73	94	**515**	**183**
1992	178	184	118	8	**519**	35
1993	**710**	**465**	**218**	144	**779**	**176**
1994	N/A	N/A	N/A	N/A		
Thresh-old Esc. Level	300	300	150	150	300	150
Recov. Esc. Level	968	610	441	389	1669	405

Table 6. Estimated cohort replacement rates (= spawner-to-spawner ratios) for five subpopulations of Snake River spring/summer chinook salmon for recent years. Estimates from Idaho Dept. of Fish and Game and Oregon Dept. of Fish and Wildlife, based on expanded redd counts and age structure in index areas (Wilson 1995). Replacement rates greater than 1.0 are necessary for population growth.

Last Esc. Year	Brood Year	Bear Valley / Elk Creeks	Imnaha River	Marsh Creek	Minam River	Poverty Flats of S. Fork Salmon River	Sulphur Creek
1985	1980	5.7	3.1	10.1	4.3	1.7	3.4
1986	1981	1.7	1.4	1.6	6.9	2.3	6.5
1987	1982	4.7	1.7	3.5	1.5	1.6	9.6
1988	1983	6.8	1.9	7.5	3.8	3.2	5.4
1989	1984	1.0	0.5	0.8	1.2	1.1	N/A[1]
1990	1985	0.5	0.4	0.5	0.3	0.9	1.4
1991	1986	1.0	0.5	0.5	0.5	1.9	0.5
1992	1987	0.2	0.3	0.3	0.1	0.8	0.6
1993	1988	0.7	0.9	0.7	0.3	0.8	0.6
1994	1989	N/A	N/A	N/A	N/A	N/A	N/A

Footnote:
[1] No redds observed in index area.

(b). <u>Snake River Fall Chinook Salmon</u>

The NMFS finds that the threshold escapement level for Snake River fall chinook salmon is 300 adult spawners, as recommended by the BWRG , is reasonable for the reasons discussed in (NMFS 1995a). A corresponding number of adults at Lower Granite Dam was not suggested by the BRWG (1994), but can be approximated by adjusting counts of natural adults at Lower Granite to account for fallback rate (e.g., 31.6% in 1992; Mendel et al. 1993) and prespawning mortality (approximately 15%; Chapman pers. comm. in Fisher et al. 1993). Therefore, an approximation of the threshold escapement level at Lower Granite Dam would be 519 ($[300 \div [(1.0 - 0.32) * (1.0 - 0.15)]$) natural adults past Lower Granite. With the exception of 1992 and 1993 returns, escapements have been below this approximate threshold level, as well as below a cohort replacement rate of one, in recent years (Table 7). The draft Recovery Plan defines a recovery escapement level as 2500 spawners and leaves estimation of a corresponding value at Lower Granite Dam to a Scientific Oversight Committee. Using the method described above, the approximate recovery escapement level at Lower Granite Dam would be 4325 natural adults.

Table 7. Estimates of naturally-produced adults to Lower Granite Dam (adjusted to include naturally-produced adults trapped at Ice Harbor Dam). Cohort replacement rates calculated by assuming parents composed of total run. Estimates for all years except 1994 from Dygert (1994a,b). Preliminary estimate for 1994 from Loch (1995). Threshold and recovery escapement levels at Lower Granite Dam are approximations of levels defined at the spawning grounds, as described in the text.

Return Year	Natural Adults	Total Replacement Rate
1985	615	1.22
1986	482	0.90
1987	332	0.52
1988	511	0.82
1989	396	0.56
1990	114	0.14
1991	318	0.40
1992	**549**	0.72
1993	**742**	1.33
1994	[Natural Count Not Available; Total Count = 852]	
Threshold Esc. Level	[519]	
Recovery Esc. Level	[4325]	

(c). Snake River Sockeye Salmon

The BRWG did not recommend a threshold escapement level for Snake River sockeye salmon for use in a jeopardy analysis. However, the thresholds identified for spring/summer chinook and fall chinook salmon were not species-specific. Those thresholds should apply to any "large" and "small" Pacific salmon populations. Presumably the threshold for sockeye would fall between 150-300 annual spawners for each relatively isolated population comprising the evolutionary significant unit (ESU) (i.e., populations established within each lake in the Stanley Basin). As described in BRWG (1994), analyses used to estimate whether or not Snake River sockeye salmon are likely to be above the threshold will be less complex and less precise than analyses for other species based on life-cycle models.

2. Recovery Requirements

For escapement levels representing recovery, the BRWG report made provisional recommendations; however, these are now superseded by delisting criteria in NMFS' draft Recovery Plan. The following numerical escapement delisting criteria are specified in the draft Recovery Plan as eight-year geometric means: (1) Sockeye: At least 1000 naturally-produced sockeye salmon in one lake and 500 in each of two other lakes in the Stanley Basin; (2) Fall Chinook: at least 2500 naturally-produced fall chinook salmon in the lower Snake River and tributaries, excluding the lower Clearwater River; (3)Spring/Summer Chinook : a) at least 31,440 naturally-produced spring/summer chinook at Lower Granite dam; and b) at least 60% of the pre-1971 brood-year average redd counts for 80% of index areas for which at least five years of pre-1971 redd counts are available. The basis for establishment of these recovery levels is explained in detail in Chapter 3 of the NMFS Draft Snake River Salmon Recovery Plan.

c. Species Status Under Enviromental Baseline

In this second step in the application of the ESA § 7(a)(2) standards, as discussed in Section I.b, above, NMFS analyzes the effects of past and ongoing human and natural factors leading to the current status of the species or its habitat and ecosystem. The environmental baseline, to which the effects of the proposed action would be added, "includes the past and present impacts of all Federal, State, or private activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process." 50 C.F.R. § 402.02 ("effects of the action").

The action area for this consultation is that portion of the range of the listed salmon that is directly and indirectly affected by the operation of the FCRPS. This includes the mainstem Snake and Columbia Rivers, the Columbia River estuary, and that portion of the ocean habitat that is influenced by the outflow from the Columbia River.

The FCRPS is comprised of fourteen dams and reservoirs, all of which were constructed between 1938 and 1975, before the Snake River Salmon were listed pursuant to the Endangered Species Act. Unlike a new project, where the environmental baseline is simply the pre-project action area, an ongoing project presents the imprecise, if not impossible, task of appreciating the impact of the past action's effects, together with other human and natural factors, upon the current status of the species as distinguished from the likely effects from continuing the action. The direct and indirect effects of the FCRPS' construction and the past manner of its operation are part of the environmental baseline for this consultation.

The significance of this step in the analysis is for NMFS and the action agencies to put any effects of the proposed operation of the FCRPS in the context of the current status of the species. For this reason the environmental baseline is best described in terms of the species' current status and likely population trends. The relative health of the listed Snake River Salmon is critical to determining whether or not the proposed operation of the FCRPS is likely to jeopardize or adversely modify critical habitat.

With this function of the environmental baseline in mind, NMFS does not attempt to quantitatively distinguish effects attributable to past construction and operation of the FCRPS and other factors from the likely future effects. What follows is an evaluation of the listed species prospects under the environmental baseline before turning to NMFS' assessment of the effects of the proposed action.

1. Snake River Sockeye Salmon

Based on smolt-to-adult returns to the mouth of the Columbia River for the 1991 and 1992 outmigrating cohorts (0.51% and 0.26%, respectively), the expected return in 1995 from the 521 smolts that migrated from Redfish Lake in 1993 will be two adults (LaVoy 1994).

Since 1991, a captive broodstock program has been in effect and all returning adults have been spawned in captivity. The first adults produced by this program (from the 1991 returns) were released into Redfish Lake to spawn in 1993 and their progeny are expected to outmigrate in the spring of 1995. The surviving 1993 brood year adults will return to spawn in one to three years, and their progeny (the first cohort of naturally-produced spawners) will not return to spawn in Redfish Lake until three to five years after that (1999-2003). Therefore, it will be well into the next century before natural production of Snake River sockeye salmon, based upon several cohorts, can begin to be evaluated.

Given the extremely low population size, which has necessitated the captive broodstock program as an emergency measure to reduce the likelihood of imminent extinction, NMFS finds that there is a very low probability that Snake River sockeye salmon population will attain their survival requirements in their critical habitat under the continuing effects of the environmental baseline. The risk is extremely high that listed sockeye will be below the threshold escapement level of 150 fish (which applies only to naturally-produced spawners) unless and until natural production is re-established sufficiently in its critical habitat to permit evaluation. The likelihood of recovery (which only applies to spawners at least two generations removed from captive broodstock) is even less certain, since there is no recent empirical evidence to evaluate the productivity of second-generation wild fish.

In summary, it appears that the Snake River Sockeye Salmon face extreme risks as a result of the environmental baseline, such that there must be a substantial improvement in the environmental conditions of its critical habitat from those currently available under the environmental baseline. Any further degradation in these conditions is significant in the face of such risk under the environmental baseline.

2. Snake River Spring Summer Chinook Salmon

It is unlikely that the biological requirements of listed Snake River spring/summer chinook salmon will be met under the substantial adverse effects of the environmental baseline alone. The significance of these effects is magnified by the current small population size, projected poor returns in the next one to two years, the influence of those poor returns on subsequent cohorts in 1998-2001, and the poor environmental conditions affecting the species throughout its life stages. Substantial improvements in environmental conditions under the environmental baseline are necessary to ensure the continued existence of this species.

Adult returns of Snake River spring/summer chinook salmon in 1994 were the lowest on record. The return of the spring component in 1995 is projected to be even lower, based on a strong relationship between Snake/Columbia River spring chinook jacks and the 4-year old component of adult spring chinook returns in the following year. The 1994 spring chinook jack count was less than half of the 1993 jack count, which represented the previous record low (Roler 1994). The projection for 1995 summer chinook returns is approximately the same as 1994 returns (TAC 1994), which were the lowest on record.

The spring component of Snake River spring/summer chinook salmon is unlikely to increase significantly in 1996 since the five-year old component of the 1996 return will be coming from the very low 1991 brood (Table 4) and the juvenile outmigration of the four-year old component occurred under below-average flow conditions in 1994 (see section IV.A.1). There is, therefore, little reason to anticipate that returns of the spring component of Snake River spring/summer chinook salmon will increase substantially until the 1993 brood year contributes to the returns in 1997 and 1998. The 1993 brood will be of particular importance because it is the last year with a substantial escapement of wild fish. After 1998, returns will again be influenced by the very low 1994 and expected low 1995 brood years. Again, because spring chinook are generally the stronger component, this situation is also likely to represent the entire Snake River spring/summer chinook ESU.

The combination of escapements that are well below threshold levels in most years since 1989 for four of the five subpopulations in Table 5 and for an estimate of the aggregate at Lower Granite Dam (Table 2) and the expectation of low returns for the next 1-2 years suggests that the likelihood of survival and recovery in the near future under current conditions is low. This assessment is in agreement with an analysis of risk associated with the "recent" time period represented by 1977-1988 brood years (1981-1993 return years) included in BRWG (1994). Analyses using both the stochastic (SLCM) and empirical (ELCM) life-cycle models suggested low probabilities of survival and recovery for most stocks, given recent conditions and current population levels, over "short-term" (24 year) and "long-term" (48 and 100 year) simulations.

The improvement over survival levels associated with the environmental baseline that are needed to reach an acceptable probability of survival and recovery is unknown. The improvement in survival over current conditions that is necessary is dependent upon assumptions used in analyses, but may be very high. Analyses conducted using the ELCM life-cycle model suggest that the density-independent component of the recent overall egg-to-adult survival rate, as determined from 1977-1988 brood year performance and present population levels, would have to increase at least 200-300% to achieve a likelihood of being above the threshold escapement level that is greater than 50-75% of the likelihood associated with a 1958-1970 historical period, when stocks were much healthier (Wilson and Schaller 1995). Analyses using the SLCM model suggest that, depending on assumptions, improvement in survival necessary to achieve the same goal may be as low as 110-150% or as high as 150-200% (Paulsen 1995).

In summary, in the near future it is unlikely that the biological and ecological requirements of listed Snake River spring/summer chinook salmon will be met under the substantial adverse effects of the environmental baseline alone. The significance of these effects is magnified by the current small population size, projected poor returns in the next 1-2 years, the influence of those poor returns on subsequent cohorts in 1998-2001, and the poor environmental conditions affecting the species in its other life stages. The extent to which the likelihood of their survival and recovery may improve over a longer time period, were the species status only subject to the effects of the environmental baseline, has not been quantitatively estimated but, based on the needed survival improvements described above, is also limited. It is clear that substantial improvement in environmental conditions under the environmental baseline are necessary to insure the continued existence of this species.

3. Snake River Fall Chinook Salmon

The 1994 natural Snake River fall chinook escapement is expected to be well below the threshold level based on preseason projection. Unless there is information from the completed 1994 return to indicate otherwise, it is reasonable to expect that the returns will continue to decline in 1995. Fall chinook returns in the Snake River system are typically dominated by four-year old fish. The 1994 run was dominated by five-year olds with relatively weak returns of three- and four-year old fish. The low return of three-year olds is based on a record low return of two-year old fish in 1993. The low four-year old return in 1994 was based on the relatively low three-year old return in 1993. A very tentative forecast for 1995 suggests that the return will be about 60% of that in 1994, or about 500 fish to the river mouth. The expected escapements to the Snake River would be proportionately low as well.

It is not possible to make specific projections for returns of fall chinook over the next three to five years (1996-1998), but it is possible to comment generally on the prospects for greater returns. The 1991 brood is weak, based on the record low return of jacks in 1993. There was certainly sufficient escapement in 1992 and 1993 to allow for increased returns after 1995, but higher returns will depend largely on improved passage and ocean survival conditions.

The NMFS finds that the likelihood of survival and recovery of listed fall chinook salmon in the immediate future is low because of a combination of factors: (1) escapements are well below threshold levels in most years since 1985 and (2) that, even assuming only the continuing direct and indirect effects of the environmental baseline, and without factoring in cumulative effects or the likely effects of the proposed action, escapement will continue to be extremely low, at least through 1995.

In the longer run, over a 24 to 100-year period, analyses of the probability of survival and recovery of Snake River fall chinook salmon under the environmental baseline have not been conducted. However, their prospects for survival are likely to be better than in the immediate future, assuming only the continuing direct and indirect effects of the environmental baseline. This is because the level of future incidental harvest of fall chinook salmon, which is not considered as part of the environmental baseline, is a larger factor in determining their likelihood of survival and recovery than it is for either the listed spring/summer chinook or sockeye salmon. The total harvest rate of fall chinook salmon during recent years, including Canadian harvest, has ranged from 46-74% (Snake River Salmon Recovery Team 1994). Based on returns of 1988-92 cohorts, the average total U.S. harvest rate was approximately 36% (CRITFC 1994).

In summary, in the immediate future it is unlikely that the biological and ecological requirements of listed Snake River fall chinook salmon will be met under the substantial adverse effects of the environmental baseline alone due to the current small population size, projected poor returns in 1995, the influence of those poor returns on subsequent cohorts in 1998-2001, and the lag time in achieving increases in survival as a result of past implementation of habitat changes that represent a beneficial effect of the environmental baseline. A quantitative assessment of risk associated with the environmental baseline over a 24-year period is not available, but because such an analysis would not consider the impact of a U.S. fall chinook harvest, such an analysis may be expected to indicate at least a moderate likelihood of survival and recovery.

IV. PROJECT EFFECTS

A. Effects of Proposed Actions

1. Flow Augmentation

a. General Considerations

As discussed in NMFS (1991a,b,c), reduced flow through reservoirs has contributed to the decline of all three listed species of Snake River salmon. Slow passage through reservoirs increases the exposure time of juvenile salmon to predation, to higher temperatures (which increase the predation rate and susceptibility of salmon to disease), and to water quality problems such as dissolved gas supersaturation, which can sometimes occur as a result of project operations. Juvenile passage through reservoirs has been estimated to take one-third to one-half longer than through free-flowing water stretches (Raymond 1988).

Delay of adult migrants due to flow and water quality conditions is cited as a factor contributing to the decline of all three species (NMFS 1991a,b,c). High flows at dams and flow patterns that mask adult attraction flows interfere with upstream passage (Liscom et al. 1985). Low flows can also affect water quality, contributing to high temperatures that may interfere with migration (e.g., Stuehrenberg et al. 1978).

b. Effects on Juvenile Snake River Sockeye Salmon

Effects of the proposed flow augmentation on Snake River sockeye salmon mortality cannot be quantified with present information, but effects are anticipated to be similar to Snake River spring/summer chinook salmon effects (section IV.A.1.d), based on migration timing and size of fish during migration. Modeling estimates of the effect of flow augmentation, when combined with other actions, on survival of Snake River spring/summer chinook salmon is presented in section IV.A.7.b.

c. Effects on Adult Snake River Sockeye Salmon

The proposed flow augmentation is expected to have no effect on survival of adult Snake River sockeye salmon.

d. Effects on Juvenile Snake River Spring/Summer Chinook Salmon

Based upon observations of PIT-tagged Snake River spring/summer chinook salmon juveniles, migration in the Snake River past Lower Granite Dam occurs primarily between April 10 and June 20, and migration in the lower Columbia River past McNary Dam occurs primarily between April 20 and June 30 (Ross 1993a).

Daily average flows during the juvenile Snake River spring/summer chinook salmon passage season in recent years are presented in Table 8.

Table 8. Average flow (kcfs) during juvenile spring/summer chinook salmon migration period.

Snake River at Lower Granite Dam[1]			
Year	Apr 10 - Jun 20	Apr 10 - Apr 30	May 1 - Jun 20
1985	90.1	90.0	90.1
1986	115.9	95.5	124.3
1987	50.2	47.2	51.4
1988	59.5	49.7	63.6
1989	85.2	90.9	82.8
1990	70.8	60.1	75.3
1991	68.7	37.6	81.4
1992	48.3	44.2	50.0
1993	106.4	64.5	123.7
1994	61.4	55.6	63.8
Columbia River at McNary Dam[2]			
Year	Apr 20 - Jun 30	Apr 20 - Apr 30	May 1 - Jun 30
1985	208.2	209.8	207.9
1986	257.4	254.7	257.9
1987	181.9	151.1	187.5
1988	168.4	137.5	173.9
1989	217.5	220.8	216.9
1990	255.1	222.4	261.0
1991	268.7	234.8	274.8
1992	183.5	159.7	187.8
1993	235.3	129.3	254.4
1994	190.5	167.6	194.7

[1] From Fish Passage Center
[2] From COE, North Pacific Division, Reservoir Control Center

The proposed action is intended to achieve flows in the Snake River from April 10 through June 20 of at least 85 kcfs in most years. This flow level is equal to the lower bound of the flow range of 85-100 kcfs identified in NMFS (1995b) and the Recovery Plan. The proposed action attempts to meet flows in the Columbia River between April 20 and June 30 of at least 200 kcfs in most years. This flow level is lower than the flow range of 220 to 260 kcfs identified in NMFS (1995b).

An estimate of the percentage of years that the Recovery Plan flow levels are achieved in the proposed action is presented in Table 9.

Table 9. Percentage of Years the proposed action meets the

Proposed Recovery Plan flows objectives - spring/summer chinook migration periods.

	Snake River at Lower Granite		
BiOp Volume Discharge (Q)	Apr 10 - Jun 20	Apr 10 - May 31	Jun 1 - Jun 20
Q<= 16 MAF	0%	8%	8%
Q> 16 MAF and Q<= 20 MAF	0%	17%	17%
Q> 20 MAF	84%	74%	68%
		Columbia River at McNary	
BiOp Volume Discharge (Q)	Apr 20 - Jun 30	Apr 20 - May 31	Jun 1 - Jun 30
Q<= 85 MAF	0%	9%	0%
Q> 85 MAF and Q<= 105 MAF	33%	42%	33%
Q> 105 MAF	93%	78%	78%

The effect of flow on juvenile spring/summer chinook salmon mortality and identification of flow ranges associated with significant reductions in mortality are reviewed in NMFS (1995b). Results of passage model analyses, which include effects of flow measures and other proposed actions on estimated mortality of juvenile spring/summer chinook salmon, are described in section IV.A.7.b.

e. Effects on Adult Snake River Spring/Summer Chinook Salmon

The proposed flow augmentation is expected to have no effect on survival of adult Snake River spring/summer chinook salmon.

f. Effects on Juvenile Snake River Fall Chinook Salmon

Dates at which 95% of wild PIT-tagged subyearling chinook passed Lower Granite Dam were August 28, July 3, August 23 and September

1 in 1991, 1992, 1993 and 1994, respectively (Fish Passage Center 1994 and PIT-tag database, PITAGIS 1994). Migration of juvenile fall chinook salmon to dams further downstream extends much longer for fish not transported from Lower Granite Dam. The primary migration period for juvenile fall chinook salmon is defined as June 21 to August 31 in the Snake River and July 1 to August 31 in the lower Columbia River (NMFS 1995b).

Daily average flows during the juvenile Snake River fall chinook salmon passage season in recent years are presented in Table 10.

Table 10. Average Flow (kcfs) during juvenile fall chinook salmon migration period.

Snake River at Lower Granite Dam[1]			
Year	Jun 21 - Aug 31	Jun 21 - Jul 31	Aug 1 - Aug 31
1985	28.3	31.6	24.1
1986	30.6	38.0	20.7
1987	19.6	21.1	16.6
1988	47.2	22.5	51.4
1989	30.8	35.5	24.7
1990	27.6	34.4	18.7
1991	30.9	42.1	16.2
1992	19.0	23.6	13.0
1993	46.1	55.7	33.3
1994	26.0	35.9	12.9
Columbia River at McNary Dam[2]			
Year	Jun 21 - Aug 31	Jun 21 - Jul 31	Aug 1 - Aug 31
1985	106.0	117.5	90.8
1986	141.6	156.9	121.3
1987	107.1	110.3	102.8
1988	139.4	103.1	187.5
1989	99.4	105.3	91.7
1990	158.8	178.5	132.8
1991	184.8	209.5	152.1
1992	111.6	117.5	103.7
1993	141.7	161.3	115.8
1994	125.6	154.1	87.8

[1] From Fish Passage Center
[2] From COE, North Pacific Division, Reservoir Control Center

The proposed action attempts to meet flows in the Snake River between June 21 and July 31 of at least 50 kcfs in most years. This flow level is equal to the lower bound of the flow range of 50-55 kcfs identified in NMFS (1995b), but is for a shorter duration. The proposed action is intended to achieve flows in the Columbia River between July 1 and July 31 of at least 160 kcfs in most years. This flow level is less than the flow objective of 200 kcfs identified in NMFS (1995b) and the Recovery Plan and is for a shorter duration.

An estimate of the percentage of years that the Recovery Plan flow levels are achieved in the proposed action is presented in Table 11.

Table 11. Percentage of Years that BPA BiOp Study Meets Proposed Recovery Plan Flows - fall chinook Migration Periods.

	Snake River at Lower Granite				
BiOp Volume Discharge (Q)	Jun 21-Aug 31	Jun 21-Jul 15	Jul 16-Jul 31	Aug 1-Aug 15	Aug 16-Aug 31
Q<= 16 MAF	0%	46%	23%	0%	
Q> 16 MAF and Q<= 28 MAF	0%	100%	0%	0%	
Q> 28 MAF	35%	100%	55%	0%	
			Columbia River at McNary		
BiOp Discharge (Q)		Jul 1-Aug 31	Jul 1-Jul 31	Aug 1-Aug 15	Aug 16-Aug 31
Q> 200 kcfs		16%	44%	4%	2%

The effect of flow on juvenile fall chinook salmon survival and identification of desirable flow ranges are reviewed in NMFS (1995b). Results of passage model analyses, which include effects of flow measures and other proposed actions on estimated mortality of juvenile fall chinook salmon, are described in section IV.A.7.c.

g. Effects on Adult Snake River Fall Chinook Salmon

The flow augmentation of 0-200 kaf from Brownlee Reservoir in late August or early September, in association with release of 0-470 kaf or more from Dworshak Reservoir between June 21 and September 30, could potentially reduce delay of adult Snake River fall chinook salmon by reducing early September temperatures in the lower Snake River, thereby potentially increasing survival. However, empirical evidence that the volume of water proposed for fall flow augmentation would accomplish temperature reduction throughout the lower Snake River is lacking. Further, it is likely that the 470 kaf from Dworshak Reservoir will be required during the juvenile fall chinook migration period in July and early August.

A March 17, 1992, letter from R. Schmitten (NMFS) to R. Flanagan (COE) reviewed the relative benefits of providing limited water for flow augmentation during either the juvenile or adult Snake River fall chinook salmon migration periods and concluded that "until the travel time of actively migrating subyearlings is minimized, flows for juvenile summer migrants should be given priority over flows for adult Snake River fall chinook salmon." A January 19, 1993, letter from M. Tuttle (NMFS) to M. Laws (COE) reiterated the importance of adequate flow conditions for juvenile fall chinook salmon, based on a review of available information.

In summary, the availability of significant storage volumes for temperature reduction during August/September and/or flows during September for adult Snake River fall chinook salmon, based on a prioritization of water for juvenile Snake River fall chinook salmon as recommended by NMFS, will be considered in the in-season management process on an annual basis. Therefore, no effect of flow augmentation on adult Snake River fall chinook salmon can be determined at this time.

2. Effects of Spill

a. General Discussion

At some projects, fish passage efficiency (FPE; the proportion of downstream migrants that pass the dams without going through turbines) can be increased by increasing the amount of water spilled during times and seasons corresponding to each species' peak migration. Since mortality associated with passage through spillways and bypasses is less than that associated with passage through turbines (section IV.A.3.a), spill can contribute to decreased overall mortality. At transport dams, increased spill may reduce the number of fish guided into transport systems, so spill at collector dams is not included in the proposed action.

Using fish guidance efficiency (FGE; the proportion of fish passing the dams via juvenile bypass systems) values provided by NMFS for 1994 Columbia River Salmon Passage Model (CRiSP) runs, FPE values have been calculated by a method approved by the Columbia Basin Fish and Wildlife Authority for inclusion in the Detailed Fish Operating Plan (Fredricks 1993a,b).

b. Effects on Juvenile Snake River Sockeye Salmon and Snake River Spring/Summer Chinook Salmon

An estimation of FPE values resulting from FGE values and spill proposed for the 1994 through 1998 period is presented in Table 12. The FPE would be approximately equal to FGE without spill.

Table 12. Proposed action FGE and FPE values for spring migrants.[1,2]

Project	Proposed 1994-1998 Action		Reduction of percentage of fish passing through turbines (vs no spill)[3]
	FGE	FPE	
Ice Harbor	68%	(25 kcfs spill cap; flow dependent; at 85 kcfs FPE = 77%)	(flow dependent; at 85 kcfs reduction = 9%)
The Dalles	43%	48%	5%
Bonneville	40%[4]	70%	30%

[1] Fredricks (1993a)
[2] Fredricks (1993b)
[3] Calculated as (% FPE-% FGE)
[4] Assumes 90% of powerhouse flow through first powerhouse, 10% of powerhouse flow through second powerhouse.

The proposed spill, as indicated above, will result in increased FPE values, which in turn should result in reductions in mortality for juvenile Snake River spring/summer chinook salmon and Snake River sockeye salmon, relative to a no spill action. The reduction in mortality occurs because juvenile salmon passed via spill are expected to experience no greater than three percent direct mortality, whereas a mortality rate of 10% to 19% is expected for fish passing through turbines (section IV.A.3.a.). Effects of spill at all projects, in conjunction with other non-spill measures, is assessed with passage modeling described in section IV.A.7.b.

Potential negative effects of spill may occur due to gas supersaturation. Spill may also inhibit adult passage at dams. These effects are addressed for both juveniles and adults in section IV.A.2.d.

c. Juvenile Snake River Fall Chinook Salmon

An estimation of FPE values resulting from spill proposed for the 1994 through 1998 period is presented in Table 13. The FPE would be approximately equal to FGE without spill.

Table 13. Proposed action FGE and FPE values for summer migrants.[1,2]

Project	Proposed 1994-1998 Action		Reduction of Percentage of Fish Passing Through Turbines[3]
	FGE	FPE	
Ice Harbor	33%[4]	(25 kcfs cap; flow dependent; at 50 kcfs, FPE = 67%)	(flow dependent; at 50 kcfs reduction = 34%)
John Day	26%	37%	11%
The Dalles	43%	45%	2%
Bonneville	0%[5]	50%	50%

[1] Fredricks (1993a)
[2] Fredricks (1993b)
[3] Calculated as (FPE - FGE)
[4] Ceballos (1994)
[5] Assumes 100% of powerhouse flow through first powerhouse and no summer operation of submerged traveling screens

Proposed spill at Bonneville and The Dalles dams will result in increased FPE values, which in turn should result in a reduction in mortality. The reduction in mortality occurs because juvenile Snake River fall chinook salmon passed via spill are expected to experience no greater than three percent mortality, whereas a mortality rate of 5% to 15% is expected for fish passing through turbines (section IV.A.3.a). Proposed interim spill at Ice Harbor is established at 30% of instantaneous project discharge, up to a maximum of 25 kcfs. Therefore, unless 30% of instantaneous project discharge is below 25 kcfs during summer operation, FPE will vary with flow levels and likely change daily. Effects of spill at all projects, in conjunction with other non-spill measures, is assessed with passage modeling described in section IV.A.7.c.

Potential negative effects of spill may occur due to gas supersaturation. Spill may also inhibit adult passage at dams. These effects are addressed for both juveniles and adults in section IV.A.2.d.

d. Adults and Juveniles of All Three Species

Increased gas saturation levels associated with the spill levels identified by this action are not expected to affect adult and juvenile Snake River salmon mortality. However, gas supersaturation is a negative effect of spill and the precise relationship between spill levels and gas bubble trauma in juvenile and adult salmon migrating in the Columbia and Snake Rivers is not known. The EPA has established a water quality criterion of 110% of saturation at ambient temperature and pressure (EPA 1986). The states have adopted this criterion as one of their water quality standards. The state standard are exceeded each year from either involuntary spill, when river flows exceed powerhouse capacities, or voluntary spill for fish passage, or both. The total dissolved gas (TDG) levels expected from the spill levels for fish passage contained in this action will likely exceed this standard by five to ten percent at some dams during some portion of the migration period.

In 1994, an emergency spill operation was conducted at all FCRPS dams, which resulted in average TDG levels five to ten percent above the established 110% TDG standard in the tailrace sections below the spilling dams. A comprehensive biological monitoring effort found that less than one tenth of one percent of the juvenile salmonids exhibited macroscopic exterior gas bubble trauma signs and no adult salmonids or other aquatic organisms were found to exhibit these signs. Microscopic examinations of juvenile steelhead did reveal a fairly high prevalence of what were thought to be external and internal signs of gas bubble trauma. However, an in-season quality control review of the monitoring operation indicated that sampling methods may have been responsible for many of these observations (Montgomery Watson 1994).

Subsequent review of the spring 1994 monitoring results by a scientific panel convened by NMFS in June, 1994, highlighted that key information is needed about the physiological effects gas bubbles in fish and how these fish survive in the river before real-time monitoring of symptoms can be relied upon to protect fish populations. The panel recommended that this information can be obtained by carefully planned field studies and physical and biological monitoring of the river environment during spill periods. The panel concluded that signs of gas bubble trauma may be expected in salmonids inhabiting shallow water near the current water quality standard of 110% saturation. In a second meeting, in November, 1994, the panel outlined its recommended physical monitoring sites, physical monitoring equipment and protocol, biological monitoring sites, and biological observations (NMFS 1995e).

The State Fishery Agencies of Oregon, Idaho, and Washington and the Columbia River Intertribal Fish Commission, in response to requests from the state water quality management agencies, issued a "Spill and 1995 Risk Management" report in January, 1995, which addresses risks to aquatic health associated with spill at hydroelectric projects on the mainstem Snake and Columbia rivers and focuses on protection salmon stocks migrating past these dams. The report weighs the benefits of spilling water at these dams to improve passage conditions for salmon against the risks associated with increased levels of total dissolved gas. This analysis concluded that in-river juvenile salmonids exposed to gas concentrations in the 120% - 125% range over an extended period still benefit from the use of spill to avoid turbine passage mortalities, despite the adverse effects of gas bubble trauma.

Spill may impede adult passage at dams by obscuring or blocking entrances to adult fishways and causing increased fallback through the spillway. Spill levels and hours are limited to compensate for this. At Bonneville Dam, the Fish Passage Plan (FPP) specifies that daylight spill is limited to 75 kcfs between the hours of 0600 and 1900 to limit adult salmonid fallback through the spillway. Spill occurrence is generally limited to nighttime hours at The Dalles and John Day dams by the Fish Passage Center in accordance with the Appendix F of the FPP. The FPP specifies that spring spill at Ice Harbor Dam is limited to nighttime hours; however, summer spill is not.

3. Effects of Project Operation and Maintenance

a. Juveniles of All Three Species

Injury and mortality can occur through each dam passage route (turbines, spillways, ice and trash sluiceways, and juvenile fish bypass systems), but numerous studies document that loss rates through turbines are generally high relative to the other routes of passage. Direct turbine mortality can range from 8% to 19% for yearling salmon and 5% to 15% for subyearling salmon (Holmes 1952; Ledgerwood et al. 1990; Long 1968; Iwamoto et al. 1994). For both spring/summer and fall chinook salmon, spill mortality generally ranges from 0% to 3%, and juvenile bypass mortality, excluding outfall mortality, can range from 1% to 3% (Brege et al. 1987; Ledgerwood et al. 1987; Ledgerwood et al. 1990; Raymond and Sims 1980). Values of turbine, spill, and bypass mortality are not available for sockeye salmon; however, it is reasonable to assume that these values are similar to, or greater than, values for yearling chinook salmon due to size and timing of migration and due to their greater susceptibility to physical injury and mortality in project passage and handling (Gessel et al. 1988; Hawkes et al. 1991; Johnsen et al. 1990; Koski et al. 1990; Parametrix 1990). The FGE research studies conducted in 1993 support the assumption that mortality is higher for sockeye salmon than for yearling chinook salmon. Studies at McNary Dam showed that overall descaling (all screen types tested) for juvenile sockeye salmon was nearly three times higher than for yearling chinook salmon (McComas et al. 1994). Studies at The Dalles Dam indicated that overall descaling for juvenile sockeye salmon was more than three times higher than for yearling chinook salmon (Brege et al. 1994). Passage survival estimates assume that FCRPS projects are operating in compliance with standards specified in the FPP. For a variety of reasons, fish passage facilities at Snake and Columbia River projects fail to operate within optimum criteria a substantial portion of the time during the migration season (Basham 1994; Eby 1994).

Delayed mortality of salmon juveniles stressed after passing through bypass systems has not been evaluated at most dams in the Columbia River Basin. Salmon juveniles subjected to bypass-related stress may undergo significant mortality due to increased predation (Ledgerwood et al. 1990). Mortalities may occur immediately or not until days after the fish exit the bypass outfall.

The FPP and the Project Improvement for Endangered Species (PIES) proposed by the COE list numerous actions designed to improve survival of juvenile salmon during dam passage. The following actions will be implemented during the 1995 through 1998 period and are among those actions most likely to reduce juvenile mortality for all species:

(1) Upgrading of the juvenile orifice entrances at Bonneville and John Day Dams is scheduled for completion by March 1995, and April 1995, respectively. Although the reduction in mortality cannot be quantified, these improvements are expected to benefit listed salmon by reducing juvenile descaling and other fish injury.

(2) Current operation of submersible travelling screens (STS) at Ice Harbor Dam is expected to increase guidance efficiency of juvenile migrants. The complete juvenile bypass system at Ice Harbor is scheduled for installation by the spring migration in 1996.

(3) Operation of extended screens at McNary, Little Goose, and Lower Granite Dams is expected to increase guidance efficiency of juvenile migrants. In the absence of relevant survival studies, any resulting reductions in mortality cannot be quantified,

although this operation is expected to reduce mortalities. Latest installation schedule is mid-season 1996 for Lower Granite, and December 1996 for Little Goose and McNary (Barila 1994).

(4) Testing of prototype surface collection systems at Lower Granite, Ice Harbor, The Dalles, John Day, and Bonneville Dams is proposed to be conducted in the 1995-98 time period. A surface collection system at Wells Dam on the mid-Columbia River has been successful in passing a high percentage of juvenile migrants. Because of different configurations and flow dynamics at each project, it is not known if the surface collection concept would achieve similar results at lower Snake and lower Columbia River projects. Because of the uncertainties of effectiveness, unspecified schedules for testing and analysis, and, if found effective, unspecified installation schedules of permanent systems, any potential benefits cannot be quantified at this time.

(5) Improvement in the operational control of turbine units, allowing operation within one percent of peak efficiency at all eight mainstem federal dams on the Snake and Columbia Rivers, will increase survival of juvenile fish that are not guided through bypass systems. However, the BPA proposes to operate turbines outside of peak efficiency to meet firm energy commitments, which will reduce benefits for fish. Turbine survival is directly related to turbine efficiency (Long and Marquette 1967), but the precise benefits of increased turbine efficiency, especially in light of indeterminate excursions out of peak turbine efficiency, are unknown.

(6) Modification of the juvenile bypass system at Bonneville Dam to reduce the negative effects (i.e. air entrainment, flow velocity changes) of a 90 degree bend in the bypass channel is expected to benefit juvenile migrants to an undetermined degree. Construction is due to be completed by March 1995.

b. Juvenile Snake River Sockeye Salmon and Spring/Summer Chinook Salmon

Completion of the juvenile bypass system at Ice Harbor Dam should result in a reduction in mortality of migrating juvenile spring/summer chinook salmon. However, in the absence of relevant research, any resulting reduction in mortality is unquantifiable.

Prototype extended-length submersible bar screen tests at McNary Dam have demonstrated improved FGEs for spring migrants. Most recent tests in 1994 have shown mean yearling chinook guidance of 85% to 89% (McComas et al. 1994). However, descaling rates in initial test years were higher than with standard STSs (McComas et al. 1993). Testing in 1993 resulted in a reduced incidence of descaling with extended length diversion screens. Subsequent improvements, primarily addition of prototype vertical barrier screens to improve gatewell hydraulics in 1994, have shown a further decreased incidence of descaling. Descaling rates observed in test and control slots were not significantly different (McComas et al. 1994). Pending further evaluation, these screens are scheduled to be installed at McNary in 1996.

These effects, in conjunction with other actions affecting juvenile passage survival, are quantified to the extent possible in modeling analyses described in section IV.A.7.c.

c. Juvenile Snake River Fall Chinook Salmon

Completion of the juvenile bypass system at Ice Harbor Dam should result in a reduction in overall mortality of migrating juvenile fall chinook salmon. However, in the absence of relevant research, any resulting reduction in mortality is unquantifiable.

Extended-length submersible bar screen tests at McNary Dam have demonstrated improved FGE's for summer migrants, with descaling rates only slightly higher than with standard submersible travelling screens (McComas et al. 1993). Pending further evaluation, these screens are scheduled to be installed at McNary Dam in 1996. Prototype extended-length submersible bar screen tests at McNary Dam have demonstrated improved FGEs for summer migrants. Most recent tests in 1994 have shown mean subyearling chinook guidance of about 66% (McComas et al. 1994). However, until fully evaluated, potential beneficial effects of extended screens for enhancing collection capabilities at transport projects cannot be quantified.

The continuing extended seasonal operation of juvenile fish bypass facilities at Lower Granite, Little Goose and Lower Monumental Dams (extended to October 31) and McNary Dam (extended to December 31) should reduce mortality of Snake River fall chinook salmon, as fewer fish will be subjected to turbine mortality.

These effects, in conjunction with other actions affecting juvenile passage survival, are quantified to the extent possible in modeling analyses described in section IV.A.7.

d. Adults of All Three Species

Cumulative loss for adults migrating up the Columbia and Snake Rivers through the eight mainstem dams can be substantial. One estimate of loss is calculated from the difference in adult counts between dams (after adjustment for legal harvest) and represents loss and mortality. Mortality can be caused by delayed migration, fallback through turbines, illegal harvest and delayed mortality from marine mammal predation, gillnet interactions, and disease. Apparent adult loss between dams may also be due to factors other than mortality of adults, such as counting errors, double-counting fish that fall back and re-ascend ladders, straying, and tributary turnoff. The combination of these effects has led to apparent adult passage losses between Bonneville Dam and Lower Granite Dam.

Mortality due to passage through the FCRPS consists of an unknown proportion of the apparent 60.4% passage loss (based on adult fish count analysis 1985-94) of adult Snake River fall chinook salmon passing through the FCRPS (Ross 1995). Another indication of adult passage loss is data from radiotagging studies (Mendel et al. 1992; Blankenship and Mendel 1993; Liscom et al. 1985). Combined passage loss of radio-tagged fall chinook salmon during studies in the lower Snake and lower Columbia Rivers is estimated to be 39.3% (Ross 1994). This is about two-thirds of the approximate 60% average passage loss, with its inherent mortality, described above. The NMFS considers the 39.3% loss of radio-tagged fall chinook salmon to be a more representative estimate of mortality attributable to the passage through the FCRPS.

Mortality due to passage through the FCRPS consists of an unknown proportion of the apparent 30.0% passage loss (based on adult fish count analysis 1985-94) of adult Snake River spring/summer chinook salmon passing through the FCRPS (Ross 1995). Another indication of adult passage loss (i.e., not due to counting errors, double-counting fish that ascend ladders more than once, straying or tributary turnoff) is data from radiotagging studies (Bjornn et al. 1992, 1993; Shew et al. undated; J. Hunt, University of Idaho, January 19, 1994, pers. comm.). Combined passage loss of radio-tagged fish during cited studies in the lower Snake and lower Columbia Rivers is estimated to be 20.9% (Ross 1994). The NMFS considers the 20.9% loss of radio-tagged spring/summer chinook salmon to be a more representative estimate of mortality attributable to the passage through the FCRPS.

An estimated 15.4% (1985-1994) of the adult sockeye salmon are unaccounted for between Bonneville and Lower Granite dams, and are considered passage mortality (Ross 1995).

While these estimates were developed for mixed stocks of each species, it is assumed that the same loss rates apply to Snake River stocks.

Since migrating salmon generally do not feed, delays during migration can deplete limited energy reserves, increase mortality, and reduce spawning success (NMFS 1991a,b,c). Average per-project delay of all three listed Snake River salmon species at lower Columbia River dams is about one to three days when good passage conditions exist (Ross 1983; Turner et al. 1984b). Average per-project delay of spring/summer chinook salmon at a lower Snake River dam in the early 1980s was about one to two days when no spill was occurring and five to seven days during high spill (Turner et al. 1983, 1984a). The median passage delays recorded during 1993 studies at lower Snake River projects ranged from 0.6 to 1.2 days during periods of no spill to medium (40-80 kcfs) spill (Bjornn et al. 1994).

Fallback of adults through turbines or spillways can result in mortality during adult passage. The proportion of adult salmon falling back through spillways can be as high as 58% (Monan and Liscom 1975). Fallback through turbines has resulted in 22% to 41% mortality of adult steelhead (Wagner and Ingram 1973), and is assumed to be similar for adult salmon. Extended juvenile bypass system operations, discussed below, are expected to reduce the number of adult fallbacks that die as a result of direct turbine mortality. Also, operation of extended-length diversion screens at McNary, Little Goose, and Lower Granite Dams (after 1995) is expected to decrease fallback mortality.

Passage delay and survival estimates assume that FCRPS projects are operating in compliance with standards specified in the FPP. For a variety of reasons, fish passage facilities at Snake and Columbia River projects fail to operate within optimum criteria a substantial portion of the time during the migration season (Basham 1994; Eby 1994).

The FPP and the PIES proposed by the COE for implementation during the 1995 through 1998 period include several actions designed to improve survival of adult salmon during dam passage. The completion of the juvenile bypass system at Ice Harbor Dam by 1996, the continued implementation of the 75 kcfs daytime spill cap at Bonneville Dam, and the continuing extended operation of juvenile bypass systems at Lower Granite, Little Goose, Lower Monumental and McNary Dams are actions that should reduce fallback mortality of migrating adult salmon.

High adult fish ladder temperatures at the Snake River projects during low water conditions may cause increases in adult salmon mortality. Reductions in ladder water temperatures as a result of ladder improvements are projected to begin in 1998. However, because no specific ladder modifications have been proposed, it is not possible to quantify the benefit to adult salmon passage.

Several other actions in the PIES are in progress and expected to be completed during the 1995 through 1996 time period. Although the benefits cannot be quantified at this time, the following PIES actions are among the most likely to reduce adult mortality for all species:

(1) Sources of adult fishway contamination will be identified and controlled at all projects by 1995.

(2) At Bonneville Dam, the first powerhouse adult fishway entrances and controls will be modified to improve passage conditions and reliability by 1996.

(3) At McNary, Lower Monumental, Little Goose, and Lower Granite Dams, adult fishway control systems will be computerized to allow better and more reliable control of the adult fishway.

These improvements are expected to benefit listed species during the 1995 through 1998 period.

e. Adult Snake River Sockeye Salmon and Adult Snake River Spring/Summer Chinook Salmon

The completion of the juvenile bypass system at Ice Harbor Dam by 1996 should reduce the mortality of adult Snake River spring/summer chinook salmon and Snake River sockeye salmon which fall back through project turbines. Adults that would have fallen back through the turbines will be guided through the juvenile bypass system and returned to the river.

Adult salmonid fallbacks through the Lower Granite Dam juvenile bypass system were counted, by species, during 1991. Applying the 22% to 41% range of turbine passage mortality yields an estimated increase in survival ranging from 0.06% to 0.1%. This estimation assumes that the 1991 chinook salmon juvenile bypass system fallback rate and the weighted average of the 1990 and 1991 re-ascension rates (from McNary Dam research) may be applied to an analysis of fallback mortality changes at Ice Harbor Dam (from 1996-98) due to the future operation of STSs and the associated complete juvenile bypass systems (Reck 1994).

High adult fish ladder water temperatures at the Snake River projects during summer may cause increases in adult Snake River spring/summer chinook salmon mortality. Reductions in ladder water temperatures as a result of ladder improvements are projected to begin in 1998. However, because no specific ladder modifications have been proposed, no benefits were assumed for this consultation.

In summary, the estimated 15.4% adult passage mortality of Snake River sockeye salmon and the estimated 20.9% adult passage mortality of Snake River spring/summer chinook salmon are expected to be reduced by an unquantifiable amount due to passage improvements expected to be in place during the 1995 through 1998 period. The expectation of reduced passage loss appears to be supported by estimation of a higher spring chinook salmon interdam passage success rate (based on differential FCRPS dam adult fish counts) for 1992, relative to other recent years (Dauble and Mueller 1993; NMFS 1994a, p. 24). However, the 1992 inter-dam passage success rate is within the range of variability of this value for the last 10 years. Therefore, although 1992 passage success rates are encouraging, it is not appropriate to quantify a declining passage loss trend until more observations are available. These actions are expected to result in decreased mortality, although the level of decrease cannot be quantified.

f. Adult Snake River Fall Chinook Salmon

The completion of the juvenile bypass systems at Ice Harbor Dam should reduce the mortality of adult Snake River fall chinook salmon which fall back through project turbines. Adults that would have fallen back through the turbines will be guided through the juvenile bypass system and returned to the river.

Adult salmonid fallbacks through the Lower Granite Dam juvenile bypass system were counted, by species, during 1991. Applying the 22% to 41% range of turbine passage mortality estimates yields an estimated increase in survival ranging from 0.7% to 1.2% at Ice Harbor Dam from 1996-98. This estimation assumes that the 1991 Lower Granite Dam fall chinook salmon juvenile bypass system fallback rate and the weighted average of the 1990 and 1991 re-ascension rates (from McNary Dam research) may be applied to an analysis of fallback mortality changes at Ice Harbor Dam due to the future operation of STSs and the associated complete juvenile bypass system (Reck 1994).

The extended seasonal operation of juvenile fish bypass facilities (through December 15) should help to reduce fallback mortality of migrating adult Snake River fall chinook salmon. A range of one to 70 migrating adult fall chinook salmon were counted per eight-hour counting period at McNary Dam in November, 1982 through 1991, indicating that substantial numbers are present at least through November. The proportion of radio-tagged fall chinook salmon fallbacks have been documented as high as 53% (8 of 15 fish) at Lower Granite Dam (Mendel et al. 1992).

High adult fish ladder water temperatures at the Snake River projects may cause increases in adult Snake River fall chinook salmon pre-spawning mortality. Decreases in ladder water temperatures as a result of ladder improvements are projected to begin in 1998. Because of migration timing, these benefits are likely to be higher for fall chinook salmon than for spring/summer chinook or sockeye salmon. However, because no specific ladder modifications have been proposed, no benefits were assumed for this consultation.

In summary, the estimated 39.3% passage mortality of adult Snake River fall chinook salmon is expected to be reduced by an unquantifiable amount due to passage improvements expected to be in place during the 1995 through 1998 period. The expectation of reduced passage loss appears to be supported by estimation of a higher inter-dam passage success rate (based on differential FCRPS dam adult fish counts) for 1992, relative to other recent years (Dauble and Mueller 1993; NMFS 1994a, p. 24). However, it is not appropriate to quantify a declining passage loss trend until more observations are available. For purposes of analysis for Snake River fall chinook salmon in this biological opinion, these actions are expected to result in an unquantifiable decrease in mortality.

4. Effects of Transportation

a. Effects on Juveniles of All Listed Species

During collection, juvenile fish are exposed to conditions that increase indices of stress. Some fish may die from handling or collection prior to loading on a barge or truck, or subsequent to their release, some mortalities may occur as a result of increased exposure to fish pathogens, and some mortalities likely occur from predation by larger salmonids in raceways or by non-salmonid predators upon release. The estimated overall facility mortality from collection at individual projects ranges from 0.3% to 6.3%, depending on the facility and the species/life stage (COE 1993).

Precise data on mortality of juveniles during transportation do not exist, although the COE estimates that seasonal average direct mortality (observable mortality prior to release) for collection and transportation combined is up to two percent (COE 1993). Stress, injury, and disease transmission are potential causes of mortality during transport. Predation by larger salmonids upon smaller ones may also occur. Research is being conducted on factors that may contribute to mortality during collection and transportation.

Elevated plasma cortisol levels associated with stress induced by marking procedures have been found to decrease significantly to pre-mark levels during truck transportation (Matthews et al. 1987). Preliminary results of another study indicate that, while initially elevated, stress indicators in juvenile salmonids (plasma cortisol, white blood cell levels, composition of white blood cells, diminished avoidance behavior) associated with collection, holding in raceways, and loading onto barges often decrease during the course of barging downriver (Schreck and Congleton 1993).

The response of juvenile salmon to collection at Lower Granite Dam and transportation by barge was assessed by measuring various physiological, performance, and behavioral traits. Preliminary 1994 results indicated that elevated plasma cortisol levels in barged chinook salmon and steelhead were largely eliminated early in the trip downriver during early and late season trials. However, at the peak of the migration, plasma cortisol levels in yearling chinook salmon remained elevated throughout collection and transportation. Plasma cortisol concentrations taken from wild and hatchery chinook salmon in barges at Lower Granite Dam were consistently and significantly higher in wild, than in hatchery fish, throughout the migration. The highest cortisol concentrations in both groups occurred during peak movement of juvenile chinook salmon into the collection facility (Schreck and Congleton 1994).

Plasma samples from chinook salmon in gatewells and barges at Lower Granite, and from barges after transport, indicated that defenses against disease pathogens were significantly decreased in the fish after transportation (Schreck and Congleton 1994).

Swimming performance of chinook salmon before and after barging was evaluated and no clear trends were observed. The ability of yearling chinook salmon sampled from a barge at Lower Granite Dam to survive a saltwater challenge was reduced on each of three successive test dates over the course of the juvenile migration (Schreck and Congleton 1994). Performance indicators are of particular interest because impaired performance can reasonably be expected to predict reduced ability to survive after release.

The behavior of fish in raceways, and in barges during transport, was examined using underwater video. Most interactions were startle responses of undetermined cause and classic aggressive behaviors were rarely observed. Immediate post-release behavior was also monitored after release from barges using radiotelemetry. The information gained may be used to evaluate the initial migration speed of downstream travel for each tagged fish, and the minimum number of tagged fish successfully migrating through the immediate release area. At release, most of the radio-tagged fish moved downstream at a rate of one to two miles per hour. This rate of movement is comparable to that observed in previous years of this study. The majority of the tagged fish probably reached the estuary in 36 to 72 hours after release (Schreck and Congleton 1994).

The incidence of bacterial kidney disease (BKD) and the potential for transmission between wild and hatchery stocks of spring/summer chinook salmon collected for transport are being investigated in ongoing research conducted by the National Biological Survey (NBS) to determine if BKD contributes to poor survival of spring/summer chinook salmon smolts (Elliott and

Pascho 1993, 1994a,b). Laboratory cohabitation and waterborne experiments indicate that *Renibacterium salmoninarum*, the causative agent of BKD, can be transmitted to healthy chinook salmon smolts during a 48-hour exposure to chinook salmon infected at levels within the range observed in yearling chinook salmon smolts during monitoring at hydroelectric dams. Results of 1992 tests indicate a high concentration level of *R. salmoninarum* ($1X10^5$ cells per milliliter) may be required for infection of greater than 50% of the exposed fish within a 48-hour exposure period (Elliott and Pascho 1994a). The incidence of BKD in migrating juvenile sockeye salmon and fall chinook salmon has not been investigated.

Based on estimated FGE’s (COE 1993), approximately 56% of outmigrating spring/summer chinook salmon, 35% of outmigrating fall chinook salmon, and 48% of outmigrating sockeye salmon may potentially be transported at Lower Granite Dam. Yearling chinook salmon guidance, as estimated by detections of PIT-tagged fish at Lower Granite from NMFS/University of Washington (UW) 1993 reach survival study groups, was slightly lower at 49.5% (Iwamoto et al. 1994). The FGE of subyearling chinook salmon has not been evaluated at Lower Granite Dam but is believed to be about 25% based on numbers of subyearlings collected at Lower Granite and Little Goose Dams and professional judgement (Ceballos 1994).
To minimize handling stress and physical injury of sampled fish, benzocaine will be administered to fish held in pre-anesthetic systems before the fish are routed to sampling troughs using water-to-water transfer. MS-222 anesthetic is administered in the sorting trough to further anesthetize fish before handling. All fish will be anesthetized in water before handling. Anesthetized fish will be allowed to fully recover before being released or loaded for transport. Quality control of collection and transportation operations will be provided by fishery biologists from the Washington Department of Fish and Wildlife (WDFW) and Oregon Department of Fish and Wildlife (ODFW).

The direct mortalities and other impacts on juvenile and adult listed salmon have been minimized over the last several years due to improvements to the transportation program such as: improvements of fish sampling methods and equipment, installation of pre-anesthetization systems, improvements to flumes, raceways and bypass pipes, and installation of larger gatewell orifices with capability for back-flushing debris, and extended transport seasons with offshore release of trucked fish. Reduction of direct mortalities as a result of these improvements have not been quantified. Improvements to the transportation program are routinely made each year based on recommendations developed from research, monitoring, and evaluation results. These improvements are expected to minimize the potential for adverse effects (including mortalities) to the listed species.

The NMFS research on transportation of juveniles has shown that collecting fish at upstream dams and transporting them below Bonneville Dam is a means to reduce loss of juveniles through the existing hydropower system and enhance the number of returning adults. From 1968 through 1980, 24 separate truck and barge transportation studies were conducted on juvenile spring/summer chinook at various dams on the Snake River (Matthews 1992). In 10 of the tests (42%), significantly more transported fish were recovered as adults than control fish, indicating higher survival for the transported group. In only one test (four percent), significantly more control fish were recovered than transported fish. In 13 tests (54%), adult recoveries were too few to identify statistical differences in returns between transported and control fish.

The survival of transported fish, compared to survival of control fish representing in-river migrants, is expressed as a transport-to-control (T/C) ratio. This ratio, based on pooled results from individual mark groups, compares the percent adult return of transported juvenile fish (test fish) to juvenile fish that migrated in-river, or juvenile fish that were transported a short distance below the marking site and then migrated in-river (control fish). Over the course of the 24 studies, T/C ratios have ranged between 0.7 and 18.1, with 3 of the studies reporting T/C ratios below one (Ebel et al. 1973; Ebel 1980; Park 1985; Slatick et al. 1975). Results of research on Snake River spring/summer chinook salmon juveniles transported by barge from Lower Granite Dam in 1986 indicate a T/C ratio of 1.6-to-1, with a 95% confidence interval (CI) between 1.01 and 2.47 (Matthews et al. 1992). Studies on spring/summer chinook salmon transported from Lower Granite Dam in 1989 indicated a T/C ratio of 2.4, with a 95% CI between 1.4 and 4.3. Results of studies at McNary Dam in 1987 suggest a positive association between transport and survival of spring chinook salmon based on a pooled T/C of 1.6-to-1 (95% CI, 1.18 to 2.25). T/C ratios for all individual mark groups were positive; however, the lower limit of the 95% CIs for three of the five groups was less than one (Achord et al. 1992). Transportation studies on spring chinook salmon at McNary Dam in 1988 resulted in a T/C ratio of 1.6, with a 95% CI between 1.0 and 2.6. Adult returns of fall chinook salmon released as juvenile transport and control groups from McNary Dam in 1986 indicate a T/C ratio of 2.8, with a 95% CI between 1.4 and 5.6 (Harmon et al. 1993). Results of studies at McNary Dam in 1987 suggest a positive association between transport and survival of subyearling chinook salmon (T/C 3.5-to-1, 95% CI 1.7 - 7.1) (Harmon et al. 1995).

While the majority of juvenile fish currently transported are of hatchery origin, early Snake River transport evaluation studies, conducted between 1968 and 1973 involved predominantly wild spring/summer chinook salmon. These studies showed significantly more adults returning from the transported than non-transported test groups (Ebel et al. 1973; Ebel 1980; Slatick et al. 1975). The T/C ratios at the dams ranged from 1.1 to 18.1; similar T/C ratios were documented at the hatcheries and spawning grounds (Ebel et al. 1973; Ebel 1980; Slatick et al. 1975).

The only data available on sockeye salmon T/C ratios were as a result of research conducted on juveniles transported by truck and barge from Priest Rapids Dam between 1984-1988 (Carlson and Matthews 1990; Carlson and Matthews 1991). Final statistical analyses of these studies have not been reported and plans for completion of a final report are unknown. However, the preliminary T/C ratios vary widely, and range from 0.55-to-1 to 4.23-to-1.

State and tribal fisheries agencies have disagreed that the transport survival studies cited above reflect estimated returns of wild adult chinook salmon to spawning areas because: (1) the T/C ratios for many of the studies were not calculated separately for wild and hatchery fish; (2) the T/C ratios for some of the studies primarily reflect the response of hatchery fish to transportation, since they comprise the majority of the fish tested; (3) the T/C ratios for many of the studies reflect adult returns to dams, and not to the spawning grounds or hatcheries; (4) some studies showed significant differences between earlier and later migrating fish, which were masked by calculating a combined T/C ratio for the entire study; and 5) transport groups were barged, whereas control groups were often trucked to release sites below the next dam downstream of the dam at which the controls were bypassed, captured and marked, resulting in an effective comparison of short and long-haul transport. (Grettenberger et al. 1993; Olney et al. 1992; STFAAT 1994). NMFS considers analyses, such as those included in section IV.A.7 of this biological opinion, which assume T/C ratios that are within the 95% CI estimated from the 1986 and 1989 studies at Lower Granite Dam, to be more realistic than analyses that assume T/C ratios that are outside of the 95% confidence intervals.

At the request of NMFS and USFWS, a review of NMFS' interpretation of available data on the benefits of transportation was completed by the Independent Peer Review Team (Team) in 1994 (Mundy et al. 1994). The Team's major findings and conclusions included, but were not limited to, the following:

1. With respect to the primary effects of juvenile fish transportation, it is more probable than not that transportation acts to improve the relative survival, as measured by recaptures of transported and untransported adults at the point of transportation, of certain species and life history types of

juvenile salmon originating in the Snake River Basin under certain hydroelectric operational scenarios and flow regimes.

2. The flow and operational scenarios that often provide positive effects on relative survival of transported salmon to the point of transportation are those associated with below average flow years with little or no spill.

3. The kinds of Snake River salmon for which transportation is likely to improve relative survival to the point of transportation are the steelhead, and to a lesser degree, the yearling-migrant stream-type chinook salmon designated as "spring/summer chinook" salmon by NMFS.

4. Research results to date are not conclusive regarding the ability of transportation to improve returns to the spawning grounds due to problems associated with experimental design.

5. There is insufficient information to determine how transportation may affect the survival of listed fall chinook salmon and sockeye salmon since available information was collected in places outside the Snake River Basin and may not be applicable inside that basin.

With respect to Item 5 above, although there have been no transport studies conducted using listed subyearling Snake River fall chinook salmon, two studies (1987-88) have been conducted using a closely related stock (mid-Columbia River fall chinook salmon) transported from McNary Dam, which must also be passed by listed Snake River fall chinook salmon. As described above, mean T/C ratios were 2.8-to-1 in 1986 and 3.5-to-1 in 1987, with 1.4-to-1 representing the lowest end of the 95% CI for the mean estimates. In these experiments, test fish transported from McNary Dam avoid the mortality associated with reservoir and project passage past three dams. The relevance of these studies to modeling assumptions is discussed in Section IV.A.7.

b. Juvenile Snake River Sockeye Salmon and Spring/Summer Chinook Salmon

Continued improvements in the collection and transport of juvenile Snake River sockeye salmon and spring/summer chinook salmon are anticipated as a result of related actions discussed in other sections of this biological opinion. Installation of extended-length screens at Lower Granite and Little Goose Dams in 1996 and 1997, respectively, are expected to result in increased FGE values and, therefore, fish passage efficiency (COE 1993). Research indicates a potential average improvement in FGE from 14% to 18% for Snake River spring/summer chinook salmon with extended-length screens at Little Goose Dam (Gessel et al. 1994). FGE of extended-length screens has not been evaluated at Lower

Granite Dam. However, based on data collected at Little Goose Dam, a potential improvement in FGE of approximately eight percent is anticipated (Ceballos 1994) Beginning in 1995, effort will concentrate on non-lethal measurement of guidance efficiency using hydroacoustics. Although fyke net losses would be avoided using this methodology, it will not be possible to discern guidance efficiency for individual species (i.e. yearling chinook salmon, sockeye salmon, and steelhead). Potential improvements in FGE of Snake River sockeye salmon with extended-length screens have not been evaluated; however, data for spring/summer chinook salmon are believed to be representative of sockeye salmon (Schiewe 1994). However, until fully installed and evaluated, expected beneficial effects of extended screens cannot be quantified.

Several COE PIES actions are expected to benefit the survival of juvenile salmon collected for transportation. Shading of the raceways at Little Goose and Lower Granite Dams will likely reduce stress for juvenile fish being held for transport by reducing solar radiation effects on water temperatures and providing refuge. Because of low water temperatures during the spring migration period, the effects of this action are likely to be less for Snake River sockeye salmon and spring/summer chinook salmon than for summer migrants. New fish barge oxygen monitoring systems and transport trailers are expected to improve conditions for Snake River sockeye salmon and spring/summer chinook salmon being transported. The potential beneficial effects of these actions are unknown pending evaluation.

Fish transported by truck from mid-June through the end of the transportation season will continue to be released mid-river, via a barge, below Bonneville Dam rather than from shore at the Hamilton Island release site as was done in the past. This action is likely to have minimal effects on juvenile Snake River sockeye salmon and spring/summer chinook salmon, due to the timing of their downstream migrations.

c. Juvenile Snake River Fall Chinook Salmon

Continued improvements in the collection and transport of juvenile Snake River fall chinook salmon are anticipated. Addition of transportation at Lower Monumental Dam increased the number of migrants available for transportation.

Several COE PIES actions are expected to benefit the survival of juvenile Snake River fall chinook salmon collected for transportation. Shading of the raceways at Little Goose and Lower Granite Dams will likely reduce stress for juvenile Snake River fall chinook salmon being held for transport by reducing effects of solar radiation on water temperatures and providing refuge. New fish barge oxygen monitoring systems and transport trailers are expected to improve conditions for Snake River fall chinook salmon being transported. These measures are expected to reduce mortality, although the level of reduction cannot be quantified at this time.

Fish transported by truck from mid-June through the end of the transportation season will continue to be released mid-river, via a barge, below Bonneville Dam rather than from shore at the Hamilton Island boat ramp, as was done in the past. This procedure is likely to reduce the ability of predators to prey on fish at a fixed release site. Mortality due to predation is most significant during summer months when water temperatures are high and subyearling chinook salmon are present (Vigg and Burley 1991). The degree of reduction in predation levels on Snake River fall chinook salmon as a result of this action cannot be quantified at this time.

d. Adult Snake River Sockeye Salmon and Adult Snake River Spring/Summer Chinook Salmon

As discussed in section IV.A.3, extended juvenile bypass system operations for the purpose of transportation are not expected to affect adult Snake River spring/summer chinook salmon or Snake River sockeye salmon, because of migration timing.

As discussed in section IV.A.4.a., research indicates that T/C ratios from adult returns of spring/summer chinook salmon are generally higher for transported fish than for control fish migrating in-river. There is less information for sockeye salmon, and the results are less clear. However, based on migration timing and size of fish during migration, under existing flow and passage conditions it is likely that transport contributes similarly to the survival of Snake River sockeye salmon and spring/summer chinook salmon, although the precise increase in survival for each species is unknown.

e. Adult Snake River Fall Chinook Salmon

As discussed in section IV.A.3, extended juvenile bypass system operations for the purpose of transportation are likely to benefit late-migrating Snake River fall chinook salmon.

As indicated in the discussion of subyearling fall chinook salmon in IV.A.4.a. above, the results of transportation research at McNary Dam in the lower Columbia indicate that T/C ratios from adult returns of fall chinook salmon are higher for transported fish than for control fish migrating in-river. Because of less favorable river conditions during the summer migration period, it is likely that transport positively affects the survival of Snake River fall chinook salmon to a greater degree than for spring migrants. However, because of the limited number of research studies involving fall chinook salmon and questions regarding the interpretation of research results identified in section IV.A.4.a., the precise increase in survival for Snake River fall chinook salmon as a result of the transportation program is not known.

5. Squawfish Removal Program

An increase in predator populations as a result of dams creating artificial habitat and concentrating prey is discussed as a factor for the decline of each listed Snake River salmon species (NMFS 1991a,b,c). Ideal foraging environments have been created above and below the hydropower dams. Smolts that pass through the projects are subjected to turbines, bypasses and spillways, resulting in disorientation and increased stress which may reduce the ability of smolts to avoid predators below the dams. Above the dams, the artificial lakes result in low water velocities which increase the smolt travel time and increase predation opportunity. Increased water temperatures, also a result of the impoundment of the river, have been shown to increase predation rates (Vigg and Burley 1991).

The system-wide squawfish removal program was not in effect prior to 1990, although a limited effort in John Day pool in 1990 resulted in removal of approximately 15,000 squawfish. Therefore, it may be assumed that no significant human-induced decreases in natural squawfish populations occurred in the Columbia and Snake Rivers prior to 1990.

The 1994-1998 FCRPS Biological Assessment states that the squawfish removal program was established with a goal of a sustained annual harvest of 10% to 20% of the adult squawfish population. The 1994-1998 FCRPS Biological Assessment estimates exploitation rates of approximately 8.5% in 1993. Oregon Department of Fish and Wildlife estimated an exploitation rate of about 13% for 1994 (Ward 1994). Because recent squawfish exploitation rates have been estimated to be at or below the program’s goals, modeling efforts discussed in section IV.B.7 have incorporated mortality reduction benefit values ranging from zero to 25%. Based on 1994 exploitation, squawfish predation in 1995 is expected to be about 65% of pre-program levels and, if average 1991-94 exploitation continues, predation is expected to stabilize at 57% of pre-program levels by the year 2000 (Ward 1994). This suggests that the assumption of a 25% reduction in total reservoir mortality (squawfish predation plus other factors) may be more reasonable than an assumption of no effect in model analyses.

6. Effect of Law Enforcement

a. Juveniles of All Three Species

Although fishery harvest enforcement, which benefits listed adult Snake River salmon, has been the primary focus of the BPA-funded law enforcement program, habitat enforcement issues were identified in 1993 that could benefit listed juvenile Snake River salmon in the future. Prosecution of illegal irrigation diversions and stream alterations has been initiated, and pumping stations that have not complied with permitting and screening requirements have been identified. However, actual removal of illegal diversions, correction of stream alterations, and installation of screens on irrigation pumps has not yet begun. Continued BPA funding is uncertain beyond 1995, and there is no firm estimate of when these corrections will occur. Therefore, it is not possible to quantify what effects this program will have on the survival of listed juvenile Snake River salmon.

b. Adults of All Species

Illegal harvest may account for a portion of the fish loss between dams on the Snake and Columbia Rivers, which was described in section IV.A.3.d. For example, in 1980 and 1981, enforcement agencies arrested dealers whose records showed that 10,200 illegal salmon had been removed from Columbia River reservoirs over a two-year period (BPA 1991). In 1982, at the trial of an illegal fish buyer, it was established that returns to the Columbia River were reduced by 250,000 pounds (approximately 12,500 salmon) as a result of illegal harvest (BPA 1991).

The proposed action for 1994 increased the number of enforcement officers by 1.75 full-time equivalent employees, compared to 1993 (Vigg 1994). This was an increase of 129% relative to the 1991 level. The proposed action for 1995 will increase the number of enforcement officers by 0.5 full-time equivalent employees compared to 1994. The proposed budget for 1995 represents an increase of approximately $206,805.00 over the 1994 budget. Additional equipment will be purchased and enforcement and public awareness programs started in 1992 will continue. This suggests that results of law enforcement activities (arrests, contacts) in 1995 are likely to increase. However, the level of law enforcement activities that will occur in 1996 and beyond is not known. Although some of the equipment provided by BPA for use by law enforcement officers is expected to continue to be useful, without additional BPA funding the law enforcement staffing levels are uncertain. The future effectiveness of the public information and awareness program may diminish without continued funding. If the program is not funded beyond 1995, the illegal harvest deterrent effect of the program may be removed completely.

Estimates of the effect of increased law enforcement on reducing mortality of listed and proposed species can only be considered conjectural. The Director of the WDFW indicated that it could result in up to a 10% increase in upstream passage survival, while a representative of the Columbia River Inter-tribal Fisheries Commission suggested that the increase in upstream passage survival would be closer to two percent (S. Vigg, BPA, February 19, 1992, pers. comm.). Preliminary data on chinook salmon inter-dam loss rates indicates a 72% reduction for the period 1992-93 (after initiation of the enhanced law enforcement program) as compared to the 1986-91 period before the enhancement of law enforcement efforts. Similarly, inter-dam loss rates for spring chinook salmon have decreased approximately 32% (in 1992-93) over the pre-enhanced law enforcement period (1977-91) (Vigg 1994). These increases, however, cannot be attributed solely to the effects of increased law enforcement, as improvements in dam passage, reductions in harvest, and other factors such as environmental variability may have also contributed to the improvements.

Because of the uncertainties discussed above, this action is expected to result in an unquantifiable decrease in mortality.

7. Summary of Effects Due to All FCRPS Actions

The combination of effects of the proposed actions on juvenile survival through the FCRPS was evaluated using computer simulation models. Details are described in NMFS (1995d). Computer simulation models for adult passage through the FCRPS were not available. Results from three juvenile passage models were considered: (1) The Columbia River Salmon Passage (Crisp.1) model (Anderson et al. 1993); (2) the Passage Analysis Model (PAM) (McConnaha 1992); and (3) the Fish Leaving Under Several Hypotheses (FLUSH) model (Weber and Petrosky 1992; Weber et al. 1992; Wilson 1994). In addition to the model documentation cited above, a general discussion of sources of uncertainty regarding assumptions and choice of parameter values in these models is contained in NMFS (1993b, 1994, 1995a); Barnthouse (1993); Barnthouse et al. (1994b).

Use of all three models was considered important, given the range of uncertainty and controversy (e.g., Anderson 1994a,b; Strong 1994) associated with modeling juvenile passage. Results of a recent workshop suggest that all three models characterize juvenile passage in a similar fashion when input is standardized and results are presented on a relative scale (Barnthouse 1993; ANCOOR 1994a). However, as discussed in NMFS (1995d), the models generally reflect competing hypotheses regarding: (1) The distribution of survival over the life span, (2) the effect of flow on survival, and (3) the benefit of transportation (Barnthouse et al. 1994b). Discussions of certain of these assumptions relative to interpreting the range of model output are included below.

Analyses of passage mortality associated with the proposed action were included in the March 16, 1994, biological opinion in Appendix D and a more detailed summary and comparison was included in ANCOOR (1994b). Significant changes in all three models were implemented since issuance of the 1994-1998 FCRPS biological opinion. These changes included structural modifications and re-calibration to additional observations. For this reason, the updated model results will be emphasized. New updated analyses of this action have been prepared for NMFS using the FLUSH and CRiSP models (NMFS 1995d) and are summarized for each species in this section. Additional analyses of similar, although not identical, spring/summer chinook salmon PAM model runs prepared for the Northwest Power Planning Council (NMFS 1995d) are also discussed.

Juvenile and adult salmon passage mortality through the FCRPS projects (reservoirs and dams) can conceptually be divided into: natural mortality that would have occurred in the pre-project river; additional mortality due to the existence of the projects; additional mortality that varies with the operation of the FCRPS; and additional mortality from other human activities. The total juvenile passage mortalities are estimated using the three available computer models. These models do not yield mortalities separated into the four conceptual categories described above. As discussed in the context of the environmental baseline above, Section II.C, NMFS knows of no scientifically reliable way to precisely apportion this mortality. In the following discussion, total passage mortality is referred to as mortality from "passage through the FCRPS," recognizing that operation of the FCRPS is only one component of the total mortality.

a. Snake River Sockeye Salmon

In addition to the effects of individual actions described previously, the combination of actions affecting juvenile Snake River sockeye salmon was evaluated, in part, with juvenile passage models used for evaluation of spring/summer chinook salmon. Juvenile Snake River sockeye salmon are likely to experience equal or greater mortality than that estimated for Snake River spring/summer chinook salmon. Similar mortality would result from the similar size and migration timing of the two species; greater mortality might result from the greater susceptibility to injury during handling, as described in section IV.A.3.a. Spring/summer chinook salmon passage model results described in section IV.A.7.b provide estimates of Snake River sockeye salmon mortality during passage through the FCRPS.

Updated model results for spring/summer chinook salmon indicate that a range of 37-82% mortality (64-82% based on FLUSH, 66-76% based on PAM, and 37-64% based on CRiSP) of juvenile Snake River sockeye salmon will occur, on average, under a range of possible hydrological conditions between 1995-1998 (NMFS 1995d). Under the worst conditions, predicted mortality would range from 39-96% (79-96% based on FLUSH, 72-86% based on PAM, and 39-64% based on CRiSP). Under the best conditions, predicted mortality would range from 35-76% (59-76% based on FLUSH, 56-62% based on PAM, and 35-60% based on CRiSP).

These model results encompass the entire range of assumptions considered by each modeling group. All results reflect assumptions of transport survival that are within the 95% confidence limits of T/C ratios estimated in recent transport survival studies (section IV.A.4) and are consistent with findings of the transport review team regarding effects of flow regimes on transport survival (Mundy et al. 1994). As discussed in section IV.A.5, NMFS gives greater weight to model results that assume a reduction, compared to pre-program years, in reservoir mortality resulting from the squawfish removal program than to results that assume no effect of the program. This would have a minor effect on FLUSH mortality estimates (64-80% mean mortality; 78-93% worst condition mortality, 59-74% best condition mortality) and no effect on PAM or CRiSP results.

As discussed in section IV.A.7.b (below), estimates from both the CRiSP and FLUSH models underestimated survival through the first 1-1/2 reservoirs, compared to the 1993 NMFS survival study described in Iwamoto et al. (1994). Although NMFS views results of both models with caution when comparing their absolute predictions to the 1993 NMFS survival study, it notes that the CRiSP model prediction was much closer to the estimated 1993 survival than the FLUSH model prediction. Therefore, NMFS places greater weight on the CRiSP model than the FLUSH model.

Mortality of adults passing through the FCRPS is expected to be 11.4%, an unknown proportion of which is expected to be caused by operation of the FCRPS. The run size forecast for 1995 is three fish to the mouth of the Columbia River (LaVoy 1994), and returns the following year may be similar. Under these conditions, mortality related to passage through the FCRPS would probably be between zero and one fish. However, in future years, returns could be larger as a result of returns from captive broodstock releases, and adult mortality, although proportionally the same, would result in higher absolute mortalities.

b. Snake River Spring/Summer Chinook Salmon

Updated model results indicate that an average of 37-82% mortality (64-82% based on FLUSH, 66-76% based on PAM, and 37-64%

based on CRiSP) of juvenile Snake River spring/summer chinook salmon will occur in 1998 under a range of possible hydrological conditions (NMFS 1995d). Under the worst conditions, mortality may be as high as 39-96% (79-96% based on FLUSH, 72-86% based on PAM, and 39-64% based on CRiSP). Under the best conditions, mortality may be as low as 35-76% (59-76% based on FLUSH, 56-62% based on PAM, and 35-60% based on CRiSP).

These model results encompass the entire range of assumptions considered by each modeling group. All results reflect assumptions of transport survival that are within the 95% confidence limits of T/C ratios estimated in recent transport survival studies (section IV.A.4) and are consistent with findings of the transport review team regarding effects of flow regimes on transport survival (Mundy et al. 1994). As discussed in section IV.A.5, NMFS gives greater weight to model results that assume a reduction, compared to pre-program years, in reservoir mortality resulting from the squawfish removal program than to results that assume no effect of the program. This would have a minor effect on FLUSH mortality estimates (64-80% mean mortality; 78-93% worst condition mortality; 59-74% best condition mortality) and no effect on PAM or CRiSP results.

As stated in section IV.A.7 and in Stelle (1995), NMFS believes that recent reach survival studies using PIT-tagged juvenile spring/summer chinook salmon represent the best available information regarding juvenile spring/summer chinook survival. Stelle (1995) responded to four objections to use of this information for assessing model performance, which were raised by Martin (1995) and re-iterated in part by the STFA Analytical Team (1995a,b), and concluded that NMFS' obligation to consider the best available scientific information dictated a comparison of model predictions with survival estimates made under current conditions with methods inherently less biased than those previously available. Stelle (1995) stated that NMFS will give greater weight to juvenile spring/summer chinook passage model survival estimates that best emulate results of recent reach survival studies, but that this would not be the only criterion upon which model performance would be assessed.

Due to time constraints, it was not possible to compare model results with two of the data sets specified in Stelle (1995): 1989-1992 PIT-tag detections between Little Goose Dam and McNary Dam and the 1994 survival study described in Muir et al. (1995). A comparison of FLUSH and CRiSP model results and a third data set, survival estimates between Nisqually John (approximately half-way between Lower Granite Dam and the head of Lower Granite reservoir) and the tailrace of Little Goose Dam from Iwamoto et al. (1994), was received from each modeling group. A weighted survival estimate for the 1-1/2 pool reach determined from

Iwamoto et al. (1994) was 77.5%, with an approximate 95% confidence interval ranging from 75%-80%.

The CRiSP model was calibrated to PIT-tag detections in the Iwamoto et al. (1994) study, as well as other PIT-tag detection data and other sources of information, such as predator indices and dissolved gas mortality experiments (Anderson 1994a,b). Possibly due to the combination of factors included in the calibration, results do not match any particular data set perfectly. The CRiSP model estimated survival of Snake River spring/summer chinook salmon from Nisqually John to the tailrace of Little Goose Dam at 70% (Anderson 1995a), which is approximately 7% lower than the lower bound of the 95% confidence interval in the Iwamoto et al. (1994) study. (NMFS notes that there was sufficient time for CRiSP modelers to compare predictions of the model with 1994 survival study results, as described in Muir et al. [1994]. The NMFS study estimated pooled survival at 65.9% and the CRiSP model estimated survival under similar conditions at 65%.)

The FLUSH estimate for the same reach was 61.5-66.8% (STFA 1995), which was 15% lower than the lower bound of the 95% confidence interval in the Iwamoto et al. (1994) study. This difference was mainly a result of the FLUSH model's estimate of partial Lower Granite reservoir and Lower Granite Dam survival. FLUSH estimates of survival from the Lower Granite tailrace to the Little Goose tailrace were similar to those of Iwamoto et al. (1994) (81.2%-84.5% with FLUSH; 86.2% [approximate 95% confidence interval 83.6%-88.8%] from PIT-tag study).

A similar comparison with the PAM model was not possible. However, reservoir survival in PAM and FLUSH is based upon the same survival estimates and a similar flow-survival relationship, so estimates from the two models tend to be similar (ANCOOR 1994a).

In summary, both the CRiSP and FLUSH models predicted survivals through the first 1-1/2 reservoirs that were lower than the 1993 juvenile spring/summer chinook salmon survival estimates, as represented by the 1993 survival study described in Iwamoto et al. (1994). Although NMFS views results of both models with caution when comparing their absolute predictions to the 1993 NMFS survival study, it notes that the CRiSP model prediction was much closer to the estimated 1993 survival than the FLUSH model prediction. Further, the CRiSP model closely predicted the results of the 1994 NMFS survival studies (no comparison was possible with the FLUSH model). Based on this, NMFS places greater weight on the CRiSP model than the FLUSH model. As stated in Stelle (1995), NMFS believes that model results should be compared to the broadest range of recent survival estimates possible and encourages each modeling group to perform these comparisons.

Passage mortality through the FCRPS consists of an unknown proportion of the 20.9% unaccounted loss of adults passing through the FCRPS (Ross 1993b). As described in section IV.A.3.d, passage loss is assumed to represent mainly adult mortality. This mortality appears to be due primarily to factors caused by the FCRPS, such as delay in migration and fallback through turbines, and due to illegal harvest, which is not directly related to the FCRPS.

The proportion of the 20.9% passage loss represented by FCRPS activities is unknown and the degree to which mortality caused by passage through the FCRPS will be reduced in 1995-1998 is also unknown, but expected to be small. For life-cycle modeling, the expected reduction was assumed to be less than one percent (Section IV.A.3.e).

c. Snake River Fall Chinook Salmon

Updated model results indicate that an average of 71-94% mortality (87-94% based on FLUSH; 71% based on CRiSP) of juvenile Snake River fall chinook salmon will occur in 1998 under a range of possible hydrological conditions (NMFS 1995d). Under the worst conditions, mortality may be as high as 73-97% (93-97% based on FLUSH; 73% based on CRiSP). Under the best conditions, mortality may be as low as 68-89% (75-89 based on FLUSH; 68% based on CRiSP).

The NMFS reviewed available empirical evidence relative to two sources of uncertainty in passage models to determine whether greater weight should be placed on a subset of the range of model estimates. The areas were survival of transported fish and the reduction in reservoir mortality related to the squawfish removal program. Reach survival estimates for in-river migrants were not reviewed because there are no new estimates based on survival of PIT-tagged fish, as there are for spring/summer chinook salmon.

NMFS considers transport assumptions that are consistent with 95% confidence limits of T/C ratios estimated in recent transport survival studies for Snake River salmon to have greater validity than assumptions that are not consistent with those observations (Toole et al. 1994; NMFS 1995d; section IV.A.7). All spring/summer chinook transport survival estimates appear to be within the 95% confidence limits of T/C ratios estimated in recent transport survival studies (Matthews et al. 1992) and are consistent with findings of the transport review team regarding effects of in-river conditions on transport survival (Mundy et al. 1994).

With respect to Snake River fall chinook salmon, the transport peer review team concluded that there was insufficient information to determine survival of transported fish (Mundy et al. 1994). The only existing studies are of run-of-river juveniles, composed of proportionately more Hanford Reach than Snake River stocks, collected at McNary Dam. The transport review team cautioned against applying these results to Snake River fall chinook salmon transported from Lower Granite Dam, since state of maturation with respect to smoltification may not be comparable at the two sites. However, since the preponderance of wild juvenile production in both rivers occurs at a similar distance above both transport dams, and the majority of wild juvenile fall chinook salmon do not begin actively migrating downstream until they attain a certain size (or state of maturation), NMFS believes it is most likely that most juveniles arrive in a similar state of maturation at both dams.

The extant literature also does not support the hypothesis put forth by the peer review team. In his review on smolt transformation, Hoar (1976) provided clear evidence that juvenile fall chinook salmon once they begin to migrate are likely in a state of maturation that would allow a gradual (and possibly sharp) transition to full-strength seawater, as would occur during post-transport (from either dam)passage through the Columbia River estuary. At a minimum, NMFS believes that it is reasonable to assume that, for the proportion of Snake River fall chinook salmon that survive to McNary Dam, transport from McNary Dam should result in T/C return ratios within the range of those observed during 1986 and 1987 (and 1988 when completed) studies (Harmon et al. 1993,1994).

Transport assumptions implemented in FLUSH (1:1 or 2:1 T/C ratio at Lower Granite Dam) result in fall chinook T/C ratios lower than the lower bound of estimates at McNary Dam (1.4-to-1 in 1986 [Harmon et al. 1993] and 1.7-to-1 [Harmon et al. 1994] in 1987), and these results will be viewed very cautiously by NMFS. However, the high T/C ratios (approximately 9:1) estimated by the CRiSP model for fall chinook salmon transported from Lower Granite Dam are not matched to any empirical evidence. T/C ratios higher than this were observed, however, for spring/summer chinook salmon transported from Little Goose Dam in 1973. In the final analysis, NMFS accepts that information about survival of transported Snake River fall chinook salmon is poorly understood and views results from both modeling systems cautiously.

NMFS will give greater weight to higher predator removal effectiveness assumptions than to the low assumption for reasons discussed relative to Snake River spring/summer chinook salmon.

B. Effects of Proposed Action, Environmental Baseline, and Other Potential Reasonable and Prudent Actions in Other Sectors Relative to Species Requirements

As described in Section III.B and NMFS (1995a), the effect of a set of actions is evaluated relative to species requirements (population levels associated with high likelihood of survival and moderate to high likelihood of recovery), based primarily on the analytical method suggested by the BRWG (1994). However, NMFS also expects that evaluation of biological requirements will require consideration of factors additional to regional life-cycle models, such as other population projections. Additionally, professional judgement will be necessary to interpret the range of model output relative to limitations of life-cycle models, the range of model output resulting from competing hypotheses, and the significance of threshold levels identified by the BRWG (1994).

Regional life-cycle models, which are the primary analytical tool used to evaluate likelihood of survival and recovery (BRWG 1994), include: (1) The Bonneville Power Administration’s Stochastic Life-Cycle Model (SLCM), developed by contractors working for Resources for the Future and the U.S. Forest Service (Lee and Hyman 1992); (2) the Northwest Power Planning Council’s System Planning Model (SPM) (NPPC 1989,1992b); and (3) the Empirical Life-Cycle Model (ELCM), developed by Oregon, Washington, and Idaho’s state fisheries agencies and the Columbia River Inter-Tribal Fishery Commission (State and Tribal Fisheries Agencies [STFA]) (Schaller et al. 1992; Schaller and Cooney 1992). The SLCM and ELCM are applied to fall and spring/summer chinook salmon. SPM only applies to spring/summer chinook salmon. In addition to the model documentation cited above, a general discussion of sources of uncertainty regarding assumptions and choice of parameter values in these models is contained in NMFS (1993b, 1994, 1995h); Barnthouse (1993); Barnthouse et al. (1994b); and section III.A.2.

Life-cycle model analyses associated with the proposed action were included in the March 16, 1994, biological opinion in Appendix C and a more detailed summary and comparison was included in ANCOOR (1994b). Significant changes in all three models were implemented since issuance of the 1994-1998 FCRPS biological opinion. These changes were both structural and the result of calibration to additional observations. For this reason, the updated model results will be emphasized. New updated analyses of this action have been prepared for NMFS using the ELCM and SLCM models (NMFS 1995d) and are summarized for each species in this section. Additional analyses of similar, although not identical, spring/summer chinook salmon SPM model runs prepared for the Northwest Power Planning Council are also discussed.

Results of passage model analyses are used as one source of input to life-cycle models. As discussed in Section IV.A.7, certain passage model assumptions and hypotheses included in passage model analyses provided to NMFS during this reconsultation were examined in relation to best available scientific information. The NMFS concluded that results based on an assumption that the predator removal program is effective in reducing reservoir mortality should be given greater weight in decision-making than the alternative assumption.

The NMFS also examined assumptions in life-cycle model sensitivity analyses and finds no compelling evidence to justify giving greater weight to one set of assumptions than another, with the following exceptions.

First, life-cycle model analyses are presented as 24-year and 100-year probabilities of being above threshold levels. NMFS believes that probabilities must be high over both time periods. However, based on comments from the model review panel regarding potential propagation of discrepancies between projections and reality (Barnthouse et al. 1994a), where conclusions from the two approaches differ, greater weight may given to the 24-year assessments.

Second, life-cycle model analyses were conducted under assumptions of depensation or no depensation at low population sizes (NMFS 1995d). A discussion of the possible role of depensation and the rationale for the form of its implementation in regional life-cycle model sensitivity analyses is included in BRWG (1994). Because the production functions underlying the life-cycle models were based upon observations of large populations and are inherently unreliable at small population sizes (Barnthouse et al. 1994a), and because it appears reasonable to assume that the number of recruits per spawner does not increase without limit as population size decreases, it is more conservative for NMFS to give greater weight to model results that are based on an assumption of depensation at low population levels.

However, NMFS acknowledges the technical disagreements among modeling teams about the method of implementing depensation in life-cycle model simulations (NMFS 1995d). In particular, the CRiSP/SLCM modeling team strongly disagrees with the method the BRWG proposed for implementing depensation, which is the method included in all FLUSH/ELCM "with depensation" analyses (Paulsen 1995b,c; Geiselman 1995). Until this issue is resolved, NMFS will view results of model runs implementing depensation with some caution.

Because results with and without this implementation had little effect on fall chinook analyses (see below), this concern applies primarily to Snake River spring/summer chinook salmon results.

Third, spring/summer chinook salmon results are presented for selected subpopulations (with production functions based on index redd counts) using the SLCM and ELCM models and as an aggregate (based on Lower Granite Dam counts) in SLCM and SPM. BRWG (1994) analyzed historic and recent trends in six subpopulations and suggested use of five subpopulations to represent the ESU. The model review panel (Barnthouse et al. 1994a) supported use of index stocks in analyses and concluded: "modeling the entire species as a single population is inappropriate because each species is actually a mixture of stocks with different productivities. The mixture will not respond in the same way as an aggregate, especially in the case where depensatory effects are assumed". Based on this consideration, NMFS will base conclusions on assessments that present results for at least five subpopulations, rather than for assessments based on the aggregate measured at Lower Granite Dam (NMFS 1995a; section I.A). However, NMFS also believes that the aggregate information is useful ancillary information, which will be considered for comparative purposes (NMFS 1995a; section IV.A).

1. Sockeye Salmon

Life-cycle model analyses were not available for this species. As recommended by the BRWG (1994), much simpler approximations of risk of not meeting biological requirements are necessary for this species. A discussion of the likelihood of survival and recovery under both current population conditions and the environmental baseline are included in section III.C. The NMFS concluded that the likelihood of both survival and recovery was low under both scenarios. Because the proposed action encompasses elements that are intermediate to current conditions and an environmental baseline consisting of no discretionary federal actions, the likelihood of survival and recovery under the proposed action is also low.

2. Spring/Summer Chinook Salmon

A discussion of the likelihood of survival and recovery under both current population conditions and the environmental baseline are included in section III.C. The NMFS concluded that the likelihood of both survival and recovery was low in the immediate future under both scenarios, due in large part to the very small current population level and the projected low returns in 1995. No life-cycle model analyses of longer-term likelihood of survival and recovery under the environmental baseline have been performed but, because of the low impact of harvest reductions in this species and the long lag time for survival to increase due to some management changes, NMFS concluded that these likelihoods were also low. Because the proposed action encompasses elements that are intermediate to current conditions and an environmental baseline consisting of no discretionary federal actions, the basic considerations stated above would lead to the conclusion that the likelihood of survival and recovery under the proposed action is also low.

The proposed action was also analyzed in a more quantitative manner using life-cycle models and the approach suggested by the BRWG (1994; see also NMFS 1995a and section I.B). Details of life-cycle model results are presented in NMFS (1995d).

Under the proposed action, the FLUSH/ELCM model results indicate that no more than three out of five spring/summer chinook index stocks have at least a 70% likelihood of being at or above the threshold level defined in NMFS (1995a) and section IV.A in the 24-year period, under all assumptions modeled by the STFA analytical team (Tables 3, 8, and 9 of NMFS 1995d). Up to four index stocks have at least a 70% probability if it is assumed that the predator removal program reduces reservoir mortality by 25% or if depensation does not occur at low population sizes. As stated previously, NMFS considers the former a reasonable conclusion but is concerned about the latter. Under other assumptions, no more than three stocks meet the criterion at this probability. No more than one of five spring/summer chinook index stocks has greater than a 50% likelihood of meeting the recovery level in 48 years.

As described in NMFS (1995d), these ELCM results do not incorporate improvements in survival due to improvements in habitat quality or changes in hatchery operations. Such changes would be inappropriate to apply to subpopulations such as Marsh Creek, Sulphur Creek, and Imnaha River, which already have good to excellent habitat and, according to STFA modelers, already account for hatchery influence in the model (Table 2 of NMFS 1995d). The Minam River subpopulation also is found in excellent habitat, so the only reasonable improvement would be from a reduction in possible straying, which is likely to have a small effect (NMFS 1993b). Bear Valley/Elk Creek is the only subpopulation modeled with ELCM that would be likely to experience a significant increase in survival if habitat improved. Based on the results described above, an improvement in survival for this stock would not change the conclusion that there is not a moderate to high likelihood of recovery in 48 years for 80% of modeled index stocks.

Additional sensitivity analyses in which harvest rates were reduced to 1.5% at low returns were also performed with ELCM (STFAAT 1995). Results were relatively insensitive to the reduced harvest rates, with the probabilities described above varying by 3% or less.

Under the proposed action, the CRiSP/SLCM results indicate that there is greater than 70% likelihood that at least four stocks will be above the threshold over a 24-year period, as long as a 25% reduction in reservoir mortality due to the predator removal program is assumed (Tables 3, 8, and 9 of NMFS 1995d). Up to four stocks also have at least a 70% probability of being above the threshold over a 100-year period if these additional assumptions hold: no depensation at low population levels and either a very low harvest rate or "high" life cycle survival improvements (egg-to-smolt survival increases 8% for Poverty Flats and 4% for other index stocks; prespawning survival increases 13% for Poverty Flats and 0% for other stocks). Under this assumption, the highest survival improvements are applied to the Poverty Flats index stock, which has the most degraded habitat, but lower survival improvements also must be applied to other index stocks in relatively high quality habitat.

CRISP/SLCM results indicate that there is a 50% chance that the recovery level will be reached for up to four stocks in 48 years if it is assumed that: there is a 25% reduction in reservoir mortality due to the predator removal program; transport survival is approximately 94% (based on T/C return ratios from Little Goose Dam of 1.6:1 in 1986 and 2.4:1 in 1989); and either (1) there is no depensation at low population levels or (2) there will be a "moderate" increase in egg-to-smolt and prespawning survival (Table 3, footnote 5, of NMFS 1995d) coupled with a reduction in harvest rate to very low levels. Under lower assumptions, fewer than four stocks meet the standard at the 50% probability level. Under no assumptions do four or more stocks meet this criterion at greater than 60% probability.

Ancillary information based on SLCM and SPM aggregate dam counts was also examined. Because a threshold has not been defined for the aggregate Snake River spring/summer chinook salmon ESU, it is impossible to directly compare life-cycle model results for the aggregate with those for index stocks. NMFS (1995a) estimated that, if an aggregate spring/summer chinook threshold were to be defined, it would probably be between 6000-12,000 spawners. BPA submitted results relative to one value, 9542 spawners, which was within this range. Probabilities relative to 9542 spawners are presented in Tables 4 and 5 of NMFS (1995d). Since the "aggregate" modeled with CRiSP/SLCM only included the spring component of the ESU, these values may underestimate the probability of the population being at or above a level comparable to the thresholds for individual stocks. For this reason, probabilities relative to a lower value (4771 spawners) will also be discussed. The spring component has comprised approximately 65% of the run in recent years, and the value of 4771 is the one submitted by BPA which falls within a range defined by 65% of 6000-12,000.

CRiSP/SLCM aggregate model runs for the proposed action led to more pessimistic conclusions, relative to results for index stocks, for the probability of being above 9542 spawners in 24 years. Only a combination of higher level assumptions modeled by BPA result in a probability of at least 70%. If aggregate results are evaluated as the probability of being above 4771 spawners in 24 years, probabilities greater than 70% are estimated under a variety of assumptions. The aggregate provided more optimistic results than the index stocks for the 100-year threshold and 48-year recovery criteria. Under a variety of assumptions, it appears that at least 70% and 50% probabilities can be met for the threshold and recovery criteria, respectively, based on CRiSP/SLCM modeling.

Results of the Northwest Power Planning Council's SPM life-cycle analyses were not presented as probabilities of being above a threshold level over 24 or 100 years, nor as probabilities of eight-year geometric means being above the recovery level in 48 years. However, results of a scenario similar to the proposed action was presented as the probability that the eight-year geometric mean would be above 5,000 or 10,000 adults at Lower Granite Dam in 24 years, and this can be roughly compared to the recovery goal.

The NPPC "Baseline" scenario was considered closest to the proposed action by NPPC staff (NMFS 1995d). For this scenario, no assumptions resulted in greater than 10% probability that recovery (here defined as an eight-year geometric mean greater than 10,000) would occur. If recovery were defined as greater than 5000 adults, probabilities ranged between approximately 20-40%, depending upon transportation survival assumption.

In summary, model results relative to survival of listed species were equivocal. FLUSH/ELCM model results indicate that the probability of being above the threshold is less than 70% for four of five index stocks over a 24-year period and, under certain assumptions, greater than 70% over 100 years. CRiSP/SLCM model results indicate that, under certain assumptions, both 24- and 100-year survival criteria can be met. Some of the necessary assumptions, such as no depensation and improvements in survival for stocks in relatively pristine habitat, do not appear as reasonable as alternative assumptions.

Neither FLUSH/ELCM or PAM/SPM results suggest that a "moderate to high" likelihood of recovery is possible. CRiSP/SLCM results suggest the recovery criterion may be met if "moderate to high" probability is considered greater than 50% and less than 60%. If this criterion is accepted, it is only met under a set of several higher level assumptions.

3. Fall Chinook Salmon

A discussion of the likelihood of survival and recovery under both current population conditions and the environmental baseline are included in section III.A.4. The NMFS concluded that the likelihood of both survival and recovery was low in the immediate future under both scenarios, due in large part to the very small current population level and the projected low returns in 1995. No life-cycle model analyses of longer-term likelihood of survival and recovery under the environmental baseline have been performed but, because of the relatively high impact of harvest reductions in this species, NMFS concluded that these likelihoods may be expected to result in a high likelihood of survival and a moderate to high likelihood of recovery. Because the proposed action encompasses elements that are intermediate to current conditions and an environmental baseline consisting of no discretionary federal actions, the basic considerations considered above would not allow one to conclude whether or not the proposed action would lead to an acceptable likelihood of survival and recovery.

The proposed action was also analyzed in a more quantitative manner with life-cycle models. Details of life-cycle model results are presented in NMFS (1995d).

Under the proposed action, the FLUSH/ELCM model results indicate that, under certain assumptions, Snake River fall chinook salmon have greater than 70% likelihood of being at or above the threshold level defined in NMFS (1995a) and section IV.A in both the 24- and 100-year periods (Tables 4, 11, and 12 of NMFS 1995d). Necessary assumptions are 1:1 or 2:1 T/C ratios from Lower Granite Dam (which result in values at McNary Dam below the 95% confidence intervals of recent transport studies) and an assumption of a 25% reduction in reservoir mortality due to squawfish removal. Short-term and long-term recovery levels were not met under any assumptions modeled by the state and tribal analytical team. Severe reductions in harvest below current levels and improvements in survival during other life stages were not examined in these analyses. Based on the effect of these assumptions in analyses of other scenarios (NMFS 1995d), their inclusion in this analysis may have resulted in more optimistic conclusions. Also, these FLUSH/ELCM fall chinook model runs for the proposed action were performed using a schedule of implementing extended-length screens at additional projects that is slower than the schedule currently proposed. Had there been sufficient time to re-run FLUSH/ELCM analyses with the proposed schedule, model results may have been somewhat more optimistic (H. Schaller, ODFW, pers. comm., February 18, 1995).

Under the proposed action, CRiSP/SLCM model results indicate that Snake River fall chinook salmon will not meet either threshold or recovery levels under any assumptions modeled by the BPA analytical team (Tables 4, 11, and 12 of NMFS 1995d). Due to time constraints, the BPA analytical team also did not model a severely reduced harvest rate in conjunction with this FCRPS operation, although BPA did model a range of survival improvements in other life stages. Inclusion of extremely low harvest rates in this analysis might have resulted in more optimistic conclusions.

C. Consistency of Proposed Action with Recovery Plan

Chapter V, Section 2 of the NMFS Recovery Plan lists the proposed Mainstem and Estuarine Ecosystem Recovery Tasks which NMFS deems necessary for the recovery of listed Snake River salmon. The action proposed by the action agencies for 1994-98 is different from the recovery tasks found in the Recovery plan in certain key respects. The proposed action relies primarily on transportation of smolts and does not include inriver improvements contained in the Recovery Plan such as significant additional volumes of augmentation water in the Columbia and increased spill at dams. The approach taken by the Recovery Plan is based on the premise that there is sufficient uncertainty about the benefits of transportation to warrant an evaluation of whether improved inriver migration may result in adult returns that are higher than adult returns from the transportation program. Accordingly, it seeks to improve inriver conditions by providing additional augmentation in the Columbia River and spill at all projects, including collector projects when flows are not low. The Recovery Plan calls for a comparison of adult return rates of transported fish with inriver migrants that have had the benefit of improved inriver conditions.

These differences that underlie the transportation evaluation are important because they lie at the heart of the adaptive management approach taken in the Recovery Plan. The state fisheries agencies’ and tribes’ view is that transportation is not part of a long term solution to Snake River salmon declines and that inriver travel, with improvements such as drawdown of reservoirs, holds greater promise. This view is based primarily on concerns about delayed mortality of transported smolts, which the FLUSH passage model assumes is in the area of 50 percent. This view cannot be fairly tested without improving inriver migration, especially through spill, and testing the adult returns from inriver migrants against adult returns from transported juveniles. Such an evaluation will help answer the larger question of whether drawdown of Snake River reservoirs should be pursued, or whether a combination of transportation and inriver travel is likely to produce the best survivals.

The proposed action also differs from the Recovery Plan in specific details about scope and duration of the action. The supplemental information submitted by the action agencies makes clear that they have expanded the scope of the consultation to include dam modifications, and implicitly the duration of the consultation to include the time necessary to implement such modifications. See, Letter from Major General Ernest J. Harrell (COE) to William W. Stelle, Jr. (NMFS) and Michael Spear (USFWS), dated December 15, 1994, and the accompanying <u>Supplemental Biological Assessment on Federal Columbia River Power Operations.</u> Although the supplemental biological assessment identifies several alternative dam modifications, it does not propose any as clear options to pursue or identify a decision path and work that must proceed for implementation of an alternative.

NMFS has concluded that without major modifications to the Snake and Columbia River dams, it is unlikely survivals can be sufficiently improved to ensure that the operation of the FCRPS does not impede the survival and recovery of listed Snake River salmon. Recognizing this, the Recovery Plan identifies three alternative scenarios for major structural modifications to the dams: spillway crest drawdown, natural river drawdown, and surface collectors. The Recovery Plan also identifies research, analyses and evaluations necessary to reach a decision on which course to pursue.

V. CUMULATIVE EFFECTS

Cumulative Effects are defined in 50 CFR 402.02 as "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation." For the purposes of this analysis, the action area encompasses the Snake and Columbia Rivers, including areas outside the range of listed Snake River salmon that affect natural runoff of water into those areas that are within the listed species' range. Future Federal actions, including the ongoing operation of hatcheries, fisheries, and land management activities are being or have been reviewed through separate section 7 consultation processes. In addition, non-Federal actions that require authorization under section 10 of the ESA will be evaluated under section 7 consultations. Therefore, these actions are not considered cumulative to the proposed action.

VI. CRITICAL HABITAT

As described in previous sections of this biological opinion, operations of the FCRPS may affect essential features of the migration corridors of listed Snake River salmon by 1) reducing water velocity due to water storage; 2) by modifying passage conditions due to placement of dams, routing of a proportion of fish through turbines, and creating optimum habitat for predators such as squawfish; 3) by modifying water quality through gas supersaturation; and 4) by increasing water temperatures. The analyses of the previous sections relates these changes in the critical habitat to changes in the mortalities of listed Snake River salmon.

The analysis of whether the proposed action jeopardizes the listed salmon (appreciably reduces the likelihood of both the survival and recovery of, the listed species) encompasses the closely related determination of whether that operation adversely modifies or destroys the listed salmon's critical habitat (appreciably diminishes the value of critical habitat for both the survival and recovery of, the listed species). In other words, section IV.A,B,C's evaluation of the relation of the proposed action to the expected mortalities of Snake River salmon combines the determinations of adverse modification of critical habitat and jeopardy into one analysis.

VII. CONCLUSIONS

NMFS' approach for determining whether a proposed action jeopardizes the continued existence of listed Snake River salmon and adversely modifies its critical habitat is discussed above in Section I.B of this opinion. As a starting point, NMFS examines the consistency of the proposed action with the Recovery Plan, which provides the best guidance for judging the adequacy of measures necessary to achieve the survival and recovery requirements for these listed species. For actions that are found inconsistent with the Plan, NMFS will evaluate whether the proposed action offers an equivalent or greater reduction in risks to species survival, using appropriate analytical tools, including passage and life cycle models.

In the case of hydropower operations, the proposed action differs in key respects from the Recovery Plan as evaluated in Section IV.C. The most prominent differences are that the Recovery Plan 1) improves in-river survival and provides a mechanism for testing the competing hypotheses regarding inriver and transportation mortalities and 2) establishes a clear path toward major system reconfigurations considered necessary to reduce adequately risks to species survival. NMFS developed the Recovery Plan only recently, and the FCRPS actions were proposed in 1994. It is therefore not surprising that the proposed action is inconsistent with the Plan. As part of the process in the <u>IDFG v. NMFS</u> discussions, and in developing the Recovery Plan and this biological opinion, NMFS analyzed the effects of the 1994 proposed action and obtained passage and life cycle modeling of the proposed action. NMFS considered this modeling, in conjunction with other analyses, to determine whether the proposed action achieved necessary reductions in risks to species survival.

In its life cycle analysis, to which the Recovery Plan is most relevant, NMFS will consider the biological requirements for spring/summer chinook to be met if there is a high likelihood, relative to the historic likelihood, that a majority of the populations will remain above the threshold levels over a 24- and 100-year period, and a moderate to high likelihood that a majority of the populations will achieve their recovery levels within 48 years. For fall chinook, the same criteria will apply except that the likelihoods must be judged in absolute terms rather than relative to some historic level of risk due to the absence of sufficient data about historic runs. For both spring/summer and fall chinook, NMFS will consider model results in its analysis.

For sockeye salmon, no life-cycle models are available. The risk to the population must therefore be assessed on the basis of a direct analysis of the likely effects of the proposed action on top of the environmental baseline and any cumulative effects, factoring in consideration of biological requirements specific to other life stages. NMFS will use qualitative evaluations only to determine whether there is a low likelihood that the species will drop below the threshold levels and a moderate to high likelihood that they will reach recovery levels in the foreseeable future.

There are three regional life cycle models that predict population responses for Snake River spring/summer chinook. These models and their significant features are described in detail in NMFS 1995d. That document explains the different "belief systems" underlying the two models: the state and tribal FLUSH model assumes high inriver mortality and high delayed mortality for transported fish, while the BPA/UW CRISP model assumes lower inriver mortality and little delayed mortality for transported fish. Given these different assumptions, it is to be expected that SLCM results would show high benefits from operations that rely heavily on transportation and low benefits from those that rely on travel time improvements, and that the reverse would be true for ELCM results.

NMFS views the results of life cycle models with great caution. They incorporate numerous assumptions, many of which necessarily must be based on biological judgment because empirical data are lacking, and they do not incorporate variables that may be important but are difficult to model (Barnthouse et al. 1994). Consistent with the advice of Barnthouse et al., NMFS views the models as most useful to indicate trends in populations and as a means to test the sensitivity of management strategies to different underlying hypotheses. The models are also useful to give a snapshot of whether there is a high or moderate probability that the species will survive and recover under a given set of assumptions and management actions. This is particularly important given the different underlying hypotheses of the two models and the opposite management approaches suggested by each.

The two models give dramatically different results when presented with the same set of management actions (NMFS 1995d). One model suggests that increased flows through reservoir drawdowns has the best chance of ensuring species survival, while a strategy that relies on transportation is likely to lead to extirpation. The other suggests that increased and improved transportation has the best chance of ensuring species survival, while a strategy that relies on drawdown is likely to lead to extirpation. These differences sharply frame the scientific issues which, in turn, define the central hypotheses that require further rigorous evaluations. The dramatically different results of the two models suggest there is great risk to the survival and recovery of the listed stocks of any management option that relies solely and conclusively on any single set of assumptions.

NMFS has concluded that CRISP passage model assumptions are more consistent with available data on passage survival and therefore the results of life cycle modeling that use CRISP results (i.e., SLCM) are due more weight (See Section IV.A.7.b). NMFS also is aware, however, that the assumptions underlying the FLUSH passage model were developed by experienced regional managers and scientists with considerable expertise in both the operations of the FCRPS and the biology of listed and other Pacific anadromous fish stocks. NMFS does not believe it is prudent to disregard the results of life cycle models that use FLUSH results (i.e., ELCM), particularly in light of the consequences of making the wrong management choice.

A. Spring/Summer Chinook

Model results relative to survival of listed species were equivocal. FLUSH/ELCM model results indicate that the probability of being above the threshold is less than 70% for four of five index stocks over a 24-year period. This conclusion applied to index stocks in good habitat with no hatchery influence and, therefore, this was not subject to possible influence of habitat improvement assumptions, as in the case of an index stock in poor habitat. Under certain assumptions, there was a probability greater than 70% that at least four index stocks would be above the threshold over 100 years. One assumption associated with this conclusion, effectiveness of the predator removal program, is considered by NMFS to be more likely than the alternative assumption modeled in FLUSH - that the program has no effect on reservoir mortality.

CRiSP/SLCM model results indicate that, under certain assumptions, both 24- and 100-year survival criteria will be met. Some of the necessary assumptions, however, do not appear as reasonable as alternative assumptions. These include the assumption of no depensation, at least when implemented in models in the manner suggested by the BRWG (NMFS 1995a), and the assumption of increases in survival due to habitat improvements and improved hatchery management for stocks in relatively pristine habitat with little or no hatchery influence.

FLUSH/ELCM results do not suggest that a "moderate to high" likelihood of recovery is possible. CRiSP/SLCM results suggest the recovery criterion may be met, but only under a set of several higher level assumptions. Either there must be no depensation, at least implemented as suggested by the BRWG, or there must be significant increases in survival due to habitat improvements and improved hatchery management for stocks in relatively pristine habitat with little or no hatchery influence. NMFS is skeptical of these assumptions. (NMFS’ decision to give greater weight to CRiSP passage modeling does not change concerns about the assumptions contained in SLCM life cycle modeling related to other parts of the life cycle such as hatchery and habitat improvements.) This is not to suggest that habitat protection is not important in good habitat, or that habitat improvements are not important in degraded habitat. Rather, the suggestion is that it may not be realistic to assume improvements in production due to habitat or hatchery improvements for stocks in pristine habitat or with little or no hatchery influence.

CRiSP/SLCM aggregate assessments based on dam counts are more optimistic for long-term survival and recovery, but somewhat more pessimistic for short-term survival. PAM/SPM aggregate results suggest that recovery is not likely under an action similar to the proposed action.

As noted earlier, NMFS views the model results as an indication of trends and a comparison of assumptions rather than an absolute prediction of expected results of particular actions. For example, NMFS is concerned not simply that survival levels are attained but also that the populations exhibit an increasing trend toward recovery. In this case, however, ELCM projects a declining population, with only one of the index stocks having a reasonably high likelihood of survival, under a range of reasonable assumptions, over the near or long term. That same index stock is the only one with a reasonable likelihood of recovery as well.

The SLCM model does not project a seriously declining population but rather an increasing one. Although survival and recovery goals are not projected for a majority of stocks under assumptions NMFS considers reasonable, results are overall fairly optimistic. These optimistic results are bolstered by analysis of the aggregate dam counts, which shows a high likelihood of survival and moderate to high likelihood of recovery. These optimistic results are not generally supported, however, by a qualitative analysis.

It is worth noting that SLCM model runs assumed surface collectors would be installed on all Snake River dams by 2002 and have an 80 percent fish passage efficiency in combination with extended screens. While surface collectors are mentioned as one alternative in the action agencies' supplemental biological assessment, there is no specific schedule or decision path ensuring their implementation. Thus, while SLCM modeling results indicate a positive trend in population, including achieving recovery of the aggregate, the results are based on assumptions about actions not specifically proposed. As noted elsewhere, they are also based on assumptions about the benefits of transportation that are questioned by state and tribal biologists. If the state and tribal assumptions are instead correct, the ELCM model indicates a downward trend in the population is likely. The combination of the incorporation of benefits from actions not specifically proposed, and the concern that plausible alternative assumptions yield dramatically different results, suggests that modeling results do not support a conclusion that the proposed action, combined with actions in other sectors, is likely to meet the biological requirements of spring/summer chinook.

Other qualitative factors support the conclusion that the species is unlikely to remain above the survival and recovery levels under the proposed action over the long term. Recent stock performance reflects a declining trend, and the recruit-to-spawner ratio for most subpopulations has been below 1 in most recent years. Projections for 1995 and 1996 returns are for all-time low returns and stock performance after 1996 is likely to be poor given current low population size and recent conditions (see Section III.A.4 discussion on Environmental Baseline). While the proposed action represents several improvements over recent conditions, those improvements are not dramatic in terms of increased survivals.

The current operation of the FCRPS has significant impacts on listed spring/summer chinook juveniles and adults, as documented in sections IV.A.1-IV.A.7. The estimates of juvenile mortality through the FCRPS are high based on SLCM (35-64%) and very high based on ELCM (59-93%). Estimates of adult mortality are also high. Although the portion of passage mortality attributable to passage through the FCRPS is not known, it is likely to be a significant factor.

While some of the proposed actions represent an improvement over the environmental baseline (such as engineering improvements at dams), these improvements will not achieve the magnitude of improvements in survival through the FCRPS contemplated in the Recovery Plan. As conditions under the environmental baseline are unlikely to meet the species' biological requirements, it is unlikely that the modest survival improvements resulting from the proposed action spanning a four-year period will meet those requirements. Improved survivals in the FCRPS of the magnitude necessary can only be achieved through long term actions that significantly reduce dam passage mortality (such as through improved fish guidance efficiency from surface collectors or removal of the effects of the dams through natural river drawdown), or long term actions that improve travel time (such as through intermediate drawdown, coupled with improved fish guidance efficiency). Although some near term system improvements are included in the proposed action, taken together they are unlikely to add up to the level of improvement necessary to contribute adequately to the species' biological requirements. Section IV.C reviews the consistency of the proposed action with the actions identified in NMFS' proposed Recovery Plan. The proposed action is inconsistent with NMFS' proposed recovery plan in significant ways. Most importantly in the short term, the proposed recovery plan calls for changes in hydropower operations that will result in improved inriver survival through spill at dams and increases in Columbia River flows. In addition, the proposed recovery plan calls for long term changes to the hydropower facilities that are expected to result in the level of survival improvements that will ensure the long-term survival and contribute adequately to the recovery of the listed stocks.

NMFS concludes that the operation of the FCRPS as described in the 1994-98 Biological Opinion is likely to jeopardize the continued existence of listed spring/summer chinook salmon and adversely modify its critical habitat because of: 1) the recent declines in spring/summer chinook populations, their current critically low levels in 1994 and projected for 1995; 2) the fact that the proposed action differs in significant respects from the Recovery Plan; 3) the fact that the FCRPS is a major limiting factor in the survival and recovery of these stocks; 4) the fact that life cycle modeling and other analyses do not indicate that the species' biological requirements will be met under different assumptions; 5) the fact that the proposed action offers only minor survival improvements over recent conditions; and 6) the fact that the only way to achieve significant improvements is with long term system reconfigurations.

NMFS places particular importance on differences between the proposed action and the Recovery Plan. The Recovery Plan takes an approach that does not commit completely to one or the other long term management approach (drawdowns versus increased transportation), which also means it does not commit completely to one or the other model, with its underlying assumptions. In addition, the Recovery Plan includes alternate major system modifications for the longer term actions that are likely to attain significant improvements in species survival.

B. Fall Chinook

Under the proposed action, the FLUSH/ELCM model results indicate that, under certain assumptions, Snake River fall chinook salmon have greater than 70% likelihood of being at or above the threshold level defined in NMFS (1995a) and section IV.A in both the 24- and 100-year periods (Tables 4, 11, and 12 of NMFS 1995h). Necessary assumptions are 1:1 or 2:1 T/C ratios from Lower Granite Dam and an assumption of a 25% reduction in reservoir mortality due to squawfish removal. The transportation assumptions result in values at McNary Dam below the 95% confidence intervals of recent transport studies, so NMFS views these results cautiously.

Under the proposed action, CRiSP/SLCM model results indicate that Snake River fall chinook salmon will not meet threshold survival levels under any assumptions modeled by the BPA analytical team.

A moderate to high probability of achieving recovery levels was not met under any assumptions modeled by the state and tribal analytical team or the BPA analytical team.

These extremely pessimistic results must be tempered to some extent. Due to time constraints, neither the STFA or BPA analytical team modeled the harvest rate called for in the Recovery Plan in conjunction with this FCRPS operation. BPA did model a range of survival improvements in other life stages but, due to time constraints, the STFA team did not. Also, these FLUSH/ELCM fall chinook model runs for the proposed action were performed using a schedule of implementing extended-length screens at additional projects that is slower than the schedule currently proposed. Had there been sufficient time to re-run FLUSH/ELCM analyses with the proposed schedule, model results may have been somewhat more optimistic (H. Schaller, ODFW, pers. comm., February 18, 1995).

Inclusion of extremely low harvest rates in this analysis would undoubtedly have resulted in higher survival levels. However, it is unlikely that conclusions would change, since the probability of meeting recovery goals, even with life-cycle improvements, was only 0-2% with CRiSP/SLCM modeling.

NMFS concludes that the operation of the FCRPS as described in the 1994-98 Biological Opinion is likely to jeopardize the continued existence of listed fall chinook salmon and adversely modify its critical habitat because of: 1) the recent declines in fall chinook populations; 2) the fact that the proposed action differs in significant respects from the Recovery Plan; 3) the fact that the FCRPS is a major limiting factor in the survival and recovery of these stocks; 4) the fact that life cycle modeling and other analyses do not predict species' biological requirements will be met under different assumptions; 5) the fact that the proposed action offers only minor survival improvements over recent conditions; and 6) the fact that the only way to achieve significant improvements is with long term system reconfigurations.

NMFS places particular importance on differences between the proposed action and the Recovery Plan. The Recovery Plan takes an approach that does not commit completely to one or the other long term management approach (drawdowns versus increased transportation), which also means it does not commit completely to one or the other model, with its underlying assumptions. In addition, the Recovery Plan includes alternate major system modifications for the longer term actions that are likely to represent significant improvements in species survival.

C. Sockeye

There are no models to predict the likelihood that species requirements for sockeye will be met in the foreseeable future. Returns have been extremely low and the captive broodstock program, while generally successful, will not produce numbers of naturally spawning fish that approach the threshold levels in the foreseeable future. It is NMFS' scientific judgment that there is a very high likelihood sockeye salmon populations will remain below the threshold level in the foreseeable future and thus that their biological requirements will not be met.

Although there are not now significant numbers of listed sockeye migrating through the FCRPS because of the captive broodstock program, there will be significant numbers once sockeye juveniles released into Redfish Lake begin to migrate. Therefore, the effects of the FCRPS proposed operations will have an increasing relevance to these sockeye as increasing numbers of fish migrating in the river system play a more important role in the survival of this species. Assuming that sockeye encounter the same or higher levels of mortalities as spring/summer chinook, passage through the FCRPS will impose a high level of mortality on these stocks.

While some of the proposed actions represent an improvement over the environmental baseline (such as engineering improvements at dams), these improvements will not achieve significant improvements in survival through the FCRPS over the long term. As conditions under the environmental baseline are unlikely to meet the species' biological requirements, it is unlikely that the survival improvements resulting from the proposed action will meet those requirements. Since significant survival improvements are necessary in the long run in order to achieve survival and recovery of the stock, an action that imposes as high a level of mortality as that imposed by the FCRPS clearly is a limiting factor on their survival and recovery.

Improved survivals in the FCRPS of the magnitude necessary can only be achieved through long term actions that improve passage mortality, such as improved passage survival through improved fish guidance efficiency or natural river drawdown, or improved travel time through drawdown. Although some near term system improvements are included in the proposed action, taken together they are unlikely to add up to the level of improvement necessary to meet the species' biological requirements.

Section IV.C reviews the consistency of the proposed action with the actions identified in NMFS' proposed recovery plan. The proposed action is inconsistent with NMFS' proposed recovery plan in significant ways. Most importantly in the short term, the proposed recovery plan calls for changes in hydropower operations that will result in improved inriver survival through spill at dams and increases in Columbia River flows. In addition, the proposed recovery plan calls for long term changes to the hydropower facilities that are expected to result in the level of survival improvements necessary to sufficiently reduce the impact of the FCRPS on listed sockeye.

NMFS concludes that the operation of the FCRPS as described in the 1994-98 Biological Opinion is likely to jeopardize the continued existence of listed spring/summer chinook salmon and adversely modify its critical habitat because of: 1) the near extirpation of sockeye populations; 2) the fact that the proposed action differs in significant respects from the Recovery Plan; 3) the fact that the FCRPS under the proposed action is a major limiting factor in the survival and recovery of these stocks; 4) the fact that life cycle considerations do not predict species' biological requirements will be met; 5) the fact that the proposed action offers only minor survival improvements over recent conditions; and 6) the fact that the only way to achieve significant improvements is with long term system reconfigurations.

VIII. Reasonable and Prudent Alternative to the Proposed Action

A. Description of the Alternative

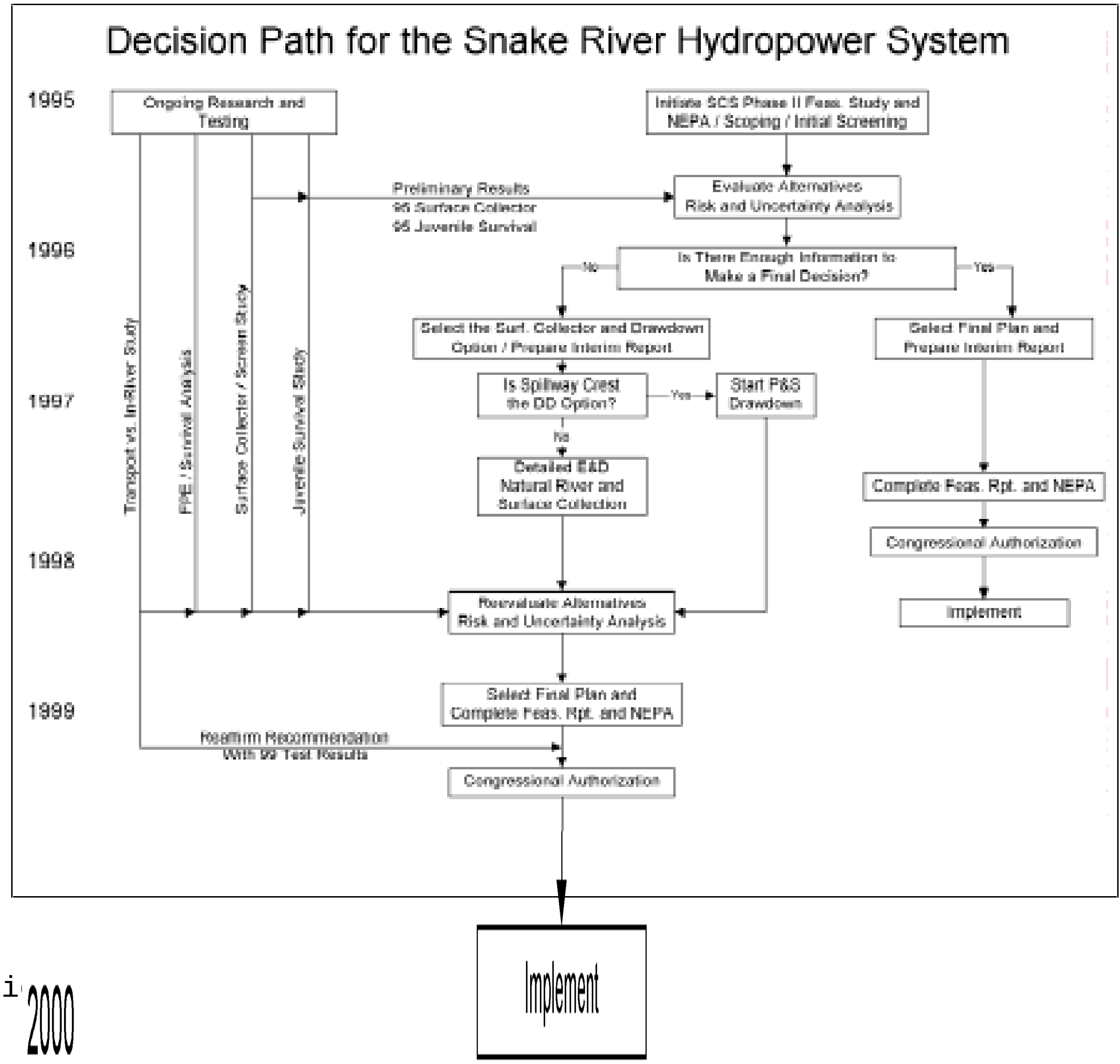
The reasonable and prudent alternative contained in this Biological Opinion identifies immediate, intermediate and long term actions that will improve the operation and configuration of the hydropower system. One of NMFS' objectives in formulating the reasonable and prudent alternative is to require implementation of all reasonable measures for the operation and configuration of the FCRPS that will reduce the mortalities of listed fish -- both to meet the no-jeopardy requirement of the ESA and to fulfill the United States' commitment to uphold tribal treaty fishing rights. The alternative employs an adaptive approach to increasing survival and the probability of recovery of listed salmon, by taking immediate actions to improve mainstem survival while reducing the uncertainty about the likely benefits of, need for and feasibility of major system structural modifications. Immediate survival improvements include improved bypasses, increased spills and spring/summer flows, reduced fish handling, better fish transportation conditions, etc. Major structural modifications include installation of surface collectors and drawdowns (natural river or spillway crest). Immediate planning and evaluations to address potential system modifications include:

1) Evaluate in-river migration versus transport under the best conditions achievable without major structural modifications, using adult returns of PIT-tagged juveniles
2) Evaluate in-river survivals using PIT tag data,
3) Install and test surface collection prototypes and evaluate their ability to improve in-river passage or collection efficiency
4) Evaluate existing data through a rigorous analysis to reduce uncertainty,
5) Complete necessary planning tasks to begin implementation of drawdown.

These evaluations are expected to provide information on:

1) The comparative benefits of in-river versus transport survival,
2) The feasibility of surface collection technology, and its ability to improve in-river survivals and/or collection efficiency,
3) The feasibility of natural river drawdown,
4) The feasibility of intermediate drawdown,
5) The ability of transportation to avoid mortalities associated with passage through the FCRPS (i.e., whether there is a high level of delayed mortality of transported smolts),
6) The adequacy of either in-river or transport survival to provide sufficient improvements in survival and a high probability for recovery in the absence of drawdowns.

There are several decision points along this path, some of which can be clearly identified and some of which must await additional information. The first preliminary decision point regarding drawdown of the Lower Snake reservoirs should be possible in 1996. By mid-1996 the reasonable and prudent alternative calls for the COE to have completed an interim evaluation report on natural river drawdown, spillway crest drawdown, and surface collectors (Figure 1). The COE should then proceed in 1996 with the engineering and design work on the preferred drawdown alternative and surface collectors, unless NMFS and the COE agree that a different course should be pursued. Engineering and design work should be completed by December 1998, followed by completion of the NEPA process and the quest for congressional authorization, to ensure that implementation of drawdown or surface collectors in the Snake River may begin by 2000.



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The evaluation of surface collection technology will proceed along the same path, except that testing of surface collectors will proceed immediately at Ice Harbor and The Dalles dams in 1995. In 1996, prototype surface collectors will be tested at Lower Granite and The Dalles dams. Surface collectors may be installed in the lower Columbia regardless of the decision on the Snake.

By late 1999 there should be sufficient information available on the two primary choices for major structural improvements at the lower Snake projects: surface collectors versus drawdowns (or possibly both if spillway crest drawdown is pursued). The year 1999 is selected as the final decision point for implementation of drawdowns primarily because of the need to collect biological information before drawdown construction begins. At the time, there will be three years of adult returns from the transportation studies and several years of information on in-river juvenile survival from PIT tag studies. This information, should help clarify whether transported fish suffer delayed loss or mortality, or whether transportation is likely to provide the highest level of survivals for downstream migrants under certain river conditions because it avoids mortalities associated with passage of downstream dams and reservoirs.

This information will also help answer the question of the level of mortality imposed on listed Snake River salmon by the FCRPS. This in turn will help answer whether sufficient survival improvements can be achieved in the hydropower system to contribute to the recovery of the listed stocks, or whether large survival improvements must be achieved in other sectors. (Under NMFS Recovery Plan, these survival benefits are called for in habitat, hatchery and harvest actions, and simultaneous evaluations will be conducted in those areas.)

Also by 1999 there will be several years of information on the feasibility and efficacy of surface collectors. This information, in combination with the information on in-river survival and transport mortality, will help clarify whether surface collectors in conjunction with an improved transportation program, or in conjunction with improved in-river conditions (i.e., increased flow and spill passage) are likely to provide the highest level of survivals for downstream migrants.

The reasonable and prudent alternative detailed in the following provisions maps out an adaptive approach. All FCRPS actions should be carefully monitored and evaluated for their value in improving survivals of listed fish. Some of these actions are new ways of operating and not all of their consequences can be anticipated. For some of the planning and evaluation actions, future steps depend on the results of earlier steps and so cannot be described in detail into the future. NMFS expects to work closely with the action agencies, state fishery agencies, Indian tribes and other regional interests to evaluate actions and propose adaptations based on emerging data. Many of the actions are accordingly described as interim, where it is clearly anticipated that they may change as new information is acquired.

The actions are divided into immediate actions to improve survivals, immediate research, evaluation and engineering studies to improve survivals in the intermediate and long term, and intermediate term actions to improve survivals.

Immediate Actions to Improve Survivals

1. Improve flows in the Columbia and Snake Rivers through additional flow augmentation, and manage those flows on an in-season basis to optimize fish survival.

a. The COE, BPA and BOR shall operate the FCRPS during the fall and winter months, in a manner that provides the following levels of confidence of refill to April 20 flood control elevations, while meeting the project and system minimum flow and flood control constraints prior to April 20: 75% at Libby and Hungry Horse, 85% at Grand Coulee beginning January 1, and 90% at Albeni Falls. (Flood control elevations in Columbia River reservoirs above the confluence with the Snake River may need to be adjusted if flood control is shifted from Snake River reservoirs.) Dworshak shall be operated on minimum outflows beginning September 1, unless drafts are required for flood control.

To ensure the reliability of the power supply, power system operators may need to draft storage projects in emergency circumstances that threaten firm loads (e.g., major temperature drops like those experienced in 1989 and 1990; loss of a major resource like Washington Nuclear Project 2 or a large Grand Coulee unit; or loss of the Northern or Southern intertie). In some circumstances, this need may conflict with fish operations described in this measure. In order to ensure the ability of the system to address such emergencies, water that is being stored for fish under the above operations may be drafted to avoid: 1) threatened inability to meet firm loads due to emergency circumstances (indicated above); or 2) voltage and transmission instability. Such drafts should be temporary and should be discussed within the TMT in advance whenever possible. The action agencies should purchase power to minimize the risk that there will be less water stored for anadromous and resident fish than would otherwise have been stored. Water may also be drafted if necessary to meet Vernita Bar flow requirements.

The BPA shall negotiate with BC Hydro and the other U.S. non-Treaty Storage Agreement signatories to mutually store water in NTS during the spring for subsequent release in July and August for flow enhancement, as long as operational forecasts indicate that water stored in the spring can be released in July and August.

During the spring and summer salmon migrations, operate the FCRPS to meet the flow objectives described in paragraph g, with the following interim limits on reservoir elevations through August 31: Grand Coulee - elevation 1280 feet; Libby - elevation 2439 feet; Hungry Horse - elevation 3540 feet; Dworshak - elevation 1520 feet. Libby may be drafted to a deeper elevation in some years to provide flows for sturgeon spawning in accordance with the Fish and Wildlife Service's Biological Opinion of March 1, 1995.

This operation substantially alters the operation of the reservoirs in the FCRPS compared to the 1993 and 1994 biological opinions. In effect, it increases the priority for the use of reservoirs for fish flow augmentation relative to power production. The impacts of this change can be seen by applying the 1995 restrictions to the actual operations in the drought years of 1992-94. According to BPA analysis, in 1992-94, 10 to 11 million acre-feet of water was shifted from the fall and winter to the spring and summer, and used for anadromous fish flow enhancement. If this 1995 Biological Opinion had been in effect from 1992-94, 13 to 16 million acre-feet (MAF) of water would have been released for salmon. This operation will increase the likelihood of achieving flow objectives in the spring by 25%, and in the summer by 90% in the Columbia River over the 1994-98 Biological Opinion levels.

Both winter operations and draft limits should be considered interim. NMFS' goal for operations of the Columbia River is to operate the FCRPS in such a way that flow targets are met during the spring chinook migration and reservoirs are full on June 30. Having reservoirs at flood control on April 20 increases the likelihood that spring flow targets will be met and the reservoirs will be full on June 30. Having reservoirs full on June 30, when natural runoff declines, results in the greatest amount of water available for the summer migration period. NMFS recognizes that this goal cannot be achieved in every year, particularly low water years. Paragraph f, which establishes an in-season management operation, identifies general guidelines for the allocation of available water.

Analysis completed by BPA indicates that under average and above average runoff conditions, operation of the hydropower system under the 1994-98 biological opinion would result in spring flow objectives being met and reservoirs being full on June 30. It may be, therefore, that NMFS' goal can be achieved with an approach that requires the upper rule curve operation only in years in which the runoff is projected to be below normal. For example, if an above average runoff is projected on January 1, the system may be able to operate less conservatively during the winter and still have a very high probability of meeting spring flow targets and being full on June 30. In particular, it may be that an operation that calls for storage of augmentation volumes above the water budget when runoff projections are below a threshold runoff volume will achieve results similar to the operation described in this measure.

The NMFS recognizes the importance of winter operations to the reliability of the hydropower system, and the fact that conservative operations are most appropriate when runoff is projected to be less than normal. Because there are many ways to describe operations of the FCRPS and there was not time to develop and model all options, NMFS intends to continue working with the action agencies, state fisheries agencies, Indian tribes and other regional interests to refine this operation. Any alternative operation, however, should have the same degree of likelihood of meeting flow targets in the spring and being full on June 30.

The NMFS considered alternative winter operations in developing its proposal. In the Detailed Fisheries Operation Plan (DFOP), state fisheries agencies and tribes recommended flow targets be met in the Columbia without specifying what hydropower operation would be used to achieve those flows. State and tribal participants in the IDFG v. NMFS discussions agreed that the modeling of hydropower operations used in the biological modeling should assume that reservoirs would be operated to upper flood control rule curve throughout the fall and winter and that reservoirs would be drafted to empty if necessary in the summer to meet flow targets. On the other side, the Power Planning Council in its December amendments adopted a flow augmentation operation that calls for storage of specified volumes at given runoff levels.

The NMFS concluded that the approach used in DFOP was unnecessarily restrictive. It gives the highest probability of having the maximum amount of water available at the beginning of the salmon migration, but in most years results in water being released for flood control in March. Under NMFS' operation, according to BPA analysis, there are only eight years in which Grand Coulee is not at the upper flood control rule curve on April 20, and in only four to five of those years is the miss in the area of 1 MAF. The additional 1 MAF that would be gained in those four to five years would come at the cost of running the system in the most conservative (and therefore expensive in terms of lost power) fashion for all 50 years. The NMFS concluded it was not reasonable to impose such a rigid operation on the system for this degree of benefit when a more flexible operation gave similar results.

On the other side, analysis conducted by BPA and the Council showed an increase in the likelihood of meeting flow targets with the operation described in this measure compared to the water budget approach, particularly in below average water years. The winter operation generally increases flows in the spring and to a lesser extent in the summer in below average water years, while the summer operations generally increase summer flows in all but the highest water years. At the same time, this operation can be expensive in terms of lost power generation. NMFS concluded it was reasonable to pursue this operation, notwithstanding the expense, because it can provide a significant increase in spring flows in below average water years and in summer flows in most water years.

Limits are placed on reservoir drafts with the goal that operations for anadromous fish do not place at risk other portions of the Columbia Basin ecosystem and the resident fish and wildlife that rely on the reservoirs. As with winter operations, NMFS considered alternative reservoir operations contained in DFOP and the Council amendments in developing its proposal. Participants in the IDFG v. NMFS discussions agreed that the modeling of hydropower operations used in the biological modeling should assume that reservoirs could be drafted to empty if necessary to meet flow targets. The Council plan adopted the "integrated rule curves" (IRC) proposed by Montana and the "water retention time" proposal of Lake Roosevelt interests to govern both winter and summer operations of Libby, Hungry Horse and Grand Coulee reservoirs.

The hydropower operations modeled to meet DFOP flow targets drafted Libby, Hungry Horse, Grand Coulee and Arrow reservoirs to empty in some years and down significantly in other years to meet flow targets. NMFS concluded that it is not reasonable to operate U.S. reservoirs in a manner that drafts them to empty or to deep levels in a significant number of years, and that it is not reasonable to assume that the United States can convince Canada to draft Arrow empty or deeply to meet flow targets for salmon. Several commenters, including upper river tribes, raised serious concerns about impacts to resident fish and wildlife. According to information submitted during the IDFG v. NMFS discussions, repeated deep drafts of reservoirs would likely have severe impacts on resident fish and wildlife.

The IRC operation adopted by the Council for Montana reservoirs generally operates Libby and Hungry Horse at lower elevations in the winter for power production. In the summer, IRCs are designed to have reservoirs full by June 30 and remain full through July and August, except during the worst water years when power needs may allow refill to lower levels. At Grand Coulee, the Council’s operation calls for a deeper draft prior to the beginning of the flood control season to ensure that the spring runoff does not "flush" out of the reservoir nutrients considered important to resident fish and aquatic organisms. The Council’s program also does not have as much water moving through Grand Coulee in July and August, (greater water movement decreases retention time). Although information was submitted during the IDFG v. NMFS process to support the biological benefits of these reservoir operations, NMFS did not find convincing the specific data that the operation contained in this measure would clearly damage resident fish and wildlife.

Conversely, NMFS concluded it was reasonable to place some limits on how deeply reservoirs could be drafted in most years. The elevations selected by NMFS are drawn from suggestions made by biologists or federal agencies during the IDFG v. NMFS discussions. There was not time to analyze fully the impact of these elevations on resident fish and wildlife and whether regular deeper drafts might have acceptable impacts on resident fish and wildlife. Accordingly NMFS concluded that the draft limits proposed were reasonable as interim limits until better information could be developed.

The benefits of meeting flow objectives are discussed in NMFS 1995b. The operation contained in this measure will increase the likelihood that flow objectives will be met, particularly in below average water years when migrating fish may need it most. In addition, this operation will result in a greater total volume of water being discharged into the estuary when migrating smolts are arriving at the estuary. It has been suggested that one of the causes of decline of listed stocks is the reduction in total discharge into the estuary during the migration period (SRSRT 1994). This reduction resulted from construction of upriver storage, particularly Libby and storage projects in Canada in the late early 1970s. This operation will mitigate that effect to a certain extent.

b. The BOR shall continue to provide the 427 thousand acre-feet (kaf) of flow augmentation from the upper Snake River as identified in the Power Planning Council's Strategy for Salmon in 1995-97, taking such actions as are necessary to ensure a high probability of providing provision of that volume by 1998. The BOR shall subsequently secure an additional amount of water, in coordination with the states of Idaho and Oregon, as may be necessary to further reduce human-caused mortality of endangered salmon in the Snake River. Consistent with the Northwest Power Planning Council's Strategy for Salmon, the BOR shall secure water for flow augmentation in a manner that is consistent with applicable state law and from willing sellers. If the BOR fails to make significant progress toward securing these volumes, formal consultation shall be initiated. The BOR should explore and pursue the most-effective means available of acquiring water including dry year leases, land fallowing, and purchases of storage space.

Additional stored water is needed for fish flow augmentation, particularly in the Snake River, in low flow years when flow objectives cannot be achieved with presently available storage volumes. The USFWS has prepared a Coordination Act Report addressing flow improvement measures for Columbia and Snake River salmon (USFWS 1993). The need for additional water for flow augmentation from the upper Snake River, Dworshak Reservoir, and the upper Columbia River is identified in the report. The CBFWA

(1991) concludes that increases in flow are essential to mitigate for disruption of the natural runoff of the Columbia and Snake Rivers as a result of dam operations. See NMFS 1995a for discussion of biological benefits.

The Power Planning Council plan calls for 1 MAF of additional stored water from the upper Snake basin above the 427 kaf identified in its original Strategy for Salmon. The state and tribal DFOP proposal calls for an additional 1.5 MAF beyond the 427 from the upper Snake. NMFS agrees that additional augmentation volumes are essential in the Snake River during low flow years and during the summer migration period and that the BOR should take all reasonable steps to secure additional water. This reasonable and prudent alternative includes a measure for BOR to ensure its ability to provide the 427 called for in the Council's original plan. The Recovery Plan calls upon BOR to pursue the acquisition of additional water after 1998 if necessary to contribute to survival and recovery of listed stocks.

During the IDFG v. NMFS discussions, both BOR and the state of Idaho provided information that it would be unlikely BOR could acquire more water in the upper Snake without resorting to condemnation. NMFS concluded that it would not be realistic to expect more water could be acquired than is specified in this biological opinion and the recovery plan. Because of concern that it will be difficult to acquire even these modest amounts of water, NMFS has included a provision that consultation may be initiated with BOR on operation of its reservoirs in the upper Snake if progress is not made toward acquiring this water.

c. The COE and the BOR shall evaluate flood control operations that provide additional storage volumes for fish flow augmentation. These operations might result from an optimization or relaxation of existing requirements, the development and use of improved streamflow forecasts, the application of structural and non-structural controls, and the implementation of additional flood control shifts between reservoirs. Such an evaluation shall consider the utility of John Day drawdown to provide additional flood control space. The agencies shall report to NMFS by November 1996, and if actions are feasible, begin implementation in December 1996.

The COE shall implement for 1996 and beyond the 1.5 MAF reallocation of flood control from Arrow to Mica, as specified in this year's February data submittal. At Grand Coulee the COE and the BOR shall add new flood control operating rule curves for the 70-95 MAF range of forecasted unregulated runoff at The Dalles to refine the operation for flood control in the months January through June.

Flood control requirements force storage reservoirs to draft water in the winter and early spring to provide space for anticipated runoff, reducing the available water in storage. Additional storage would increase flows for fish migration, especially in low water years.

d. The BPA and COE shall continue attempting to expand current arrangements for storage in Canadian reservoirs to allow additional storage for fish flow enhancement, above the current approximate 1 MAF realized in current operational agreements. This storage would be negotiated with the same principle of the current storage arrangement, which is to meet U.S. and Canadian non-power objectives in a revenue-neutral manner and on a mutually agreeable basis.

Improved operations at Arrow, including flood control reallocations and a summer draft of twenty feet (similar to drafts of U.S. reservoirs) could provide an additional 3.5 MAF of flow augmentation. NMFS recognizes that these operations would be unnecessary in above normal runoff years because in those years NMFS' goal of meeting flow targets and having full reservoirs on June 30 will be achieved. Arrangements on operation of the Canadian projects should therefore emphasize operations during average and below average runoff years. If BPA and COE fail to make significant progress toward securing additional volumes, consultation will be initiated among BPA, COE and NMFS on operational arrangements under the Detailed Operating Plan between BPA, COE and BC Hydro. For 1995, BPA and COE should immediately determine if a minimum flow operation at Arrow, would significantly increase the probability of meeting spring flow objectives.

e. For 1995, the TMT shall coordinate with Idaho Power Company for the provision of additional stored water for flow augmentation from Brownlee Reservoir if necessary to meet the flow objectives at Lower Granite. The operation would be to draft to elevation 2069 feet during May, no refill, pass inflow; draft to elevation 2067 feet in July, no refill, pass inflow; and draft to 2059 in August or September (as determined by the TMT); begin refill in September. The TMT may request alternate operations based on conditions in season. For 1996 and beyond, NMFS and Idaho Power Company will cooperate on a study of Idaho Power Company operations, including shaping of Upper Snake water, and consider adjustments to this operation. The NMFS may consult with FERC on these operations if necessary. The TMT may recommend that COE shift system flood control from Brownlee Reservoir to reservoirs in the Columbia River above the confluence with the Snake River.

f. The COE and BOR shall operate the FCRPS in coordination with an in-season Technical Management Team (TMT) throughout the year.

The TMT shall advise the operating agencies on dam and reservoir operations to optimize passage conditions for juvenile and adult anadromous salmonids. By April 1, 1995 the federal agencies participating in the TMT shall agree to operating guidelines for the TMT. Recommendations of the TMT shall be made by consensus, except that when no consensus is reached, NMFS shall make the recommendation. Recommendations shall be made to COE and BOR, which have authority to operate the FCRPS projects, and to COE and BPA, which have authority to make agreements with Canada regarding storage in Canada.

The TMT shall develop a water management plan by April 15 of each year based on the run-off forecast for that year. In general, the plan should attempt to conserve water for flow augmentation in July and August, unless doing so would result in significant departures from spring flow objectives. To achieve the conservation of water for summer flows, the plan should generally include operation of all Columbia River reservoirs to refill by June 30, with gradual releases to the draft limits through July and August.

Prior to the migration season, the TMT will review reservoir operations and address operational flexibility associated with the April 15 upper rule curve targets. The TMT may recommend that COE shift system flood control to optimize available water for fish migration. During the migration season, the TMT shall guide the use of water in the Snake and Columbia Rivers with the goal of creating hydrographic conditions that provide the greatest survivals for listed Snake River salmon, taking into account needs of other anadromous fish in the Basin. Using volume forecasts the TMT will determine how to distribute available augmentation volumes on top of runoff, and attempt to mimic the natural hydrograph, keeping in mind the goal of meeting flow objectives set out in paragraph g.

The TMT may recommend lower summer reservoir elevations if necessary to meet flow objectives depending on the circumstances of the run-off and the salmon migration (e.g., a low water year that is one in a series of low water years and an outmigrating population of fish that represents a strong year class). In general, lower summer reservoir elevations will only be recommended when the upper rule curve goals were not met on April 20 at Grand Coulee and Albeni Falls, or when The Dalles April-August unregulated runoff is expected to be less than 65 MAF, determined as of June 30. During the remainder of the year the TMT will monitor and make recommendations on operations to ensure operational planning and priorities provide for improved survival of listed Snake River salmon and other anadromous species. The TMT shall consist of representatives from COE, BPA, BOR, FWS, and NMFS. In-season management decisions shall be made in coordination with state fisheries agencies, tribes, the Idaho

Power Company, and other regional interests both directly and through the Northwest Power Planning Council’s Fish Operations Executive Committee.

NMFS received comments by states and tribes on its draft biological opinion to the effect that those entities should "have a seat at the table" in making decisions on operations of the FCRPS. NMFS agrees that state and tribal entities have management authority for Snake River and other Columbia Basin stocks and that they have expertise in river operations and their effects on anadromous stocks. Operation of the FCRPS is a federal responsibility, however, and cannot be delegated to nonfederal entities. NMFS intends to coordinate closely with state and tribal entities because of their special authorities as co-managers of the resource and because of their expertise and biological judgment. During the in-season management process in 1994, NMFS consulted with state and tribal managers through the Fish Passage Advisory Committee prior to the weekly meeting with the action agencies. State and tribal interests were invited to attend the weekly meetings with the action agencies or to be represented at the meetings by the Fish Passage Center. At a policy level, state and tribal representatives interacted with NMFS and the action agencies through the Power Planning Council’s Fish Operations Executive Committee. NMFS intends in the in-season management process to continue and strengthen its coordination with state and tribal managers in 1995 and beyond.

g. In recommending the shaping of flows in-season in accordance with the guidance in paragraph 1.a, the TMT’s recommendations shall take into account the goal of meeting a seasonal average flow objective at the locations and for the time periods as specified below.

The dates indicated are for planning purposes. Actual timing of flow augmentation will be determined in-season by the TMT.

	Snake River at Lower Granite Dam		Columbia River at McNary Dam	
Spring	4/10-6/20	85-100 kcfs	4/20-6/30	220-260 kcfs
Summer	6/21-8/31	50-55 kcfs	7/1-8/31	200 kcfs*

* Although the best biological information supports 200 kcfs as providing reduced mortality benefits for subyearling chinook salmon in the lower Columbia, decreased numbers of fish during late August may dictate that use of available water may be preferable during other times of the juvenile migration.

Spring Flows at Lower Granite Dam:

Incorporate a sliding scale for provision of flows based on the April final volume runoff forecast (and modified in-season with the final May forecast) as follows: when the April-July volume runoff forecast for Lower Granite is >16 MAF and <=20 MAF, the minimum average spring flow shall be determined by a linear interpolation between 85 kcfs and 100 kcfs. When the volume forecast for Lower Granite is >20 MAF, the target average flow will be at least 100 kcfs.

Summer Flows at Lower Granite Dam:

Incorporate a sliding scale for provision of flows based on the April final volume runoff forecast (and modified in-season with the final May forecast) as follows: when the April-July runoff forecast for Lower Granite is >16 MAF and <=28 MAF, the average summer flow shall be determined by a linear interpolation between 50 kcfs and 55 kcfs. When the volume forecast for Lower Granite Dam is >28 MAF, the target average flow will be at least 55 kcfs.

Spring Flows at McNary Dam:

When the January-July volume runoff forecast for The Dalles is >85 MAF and <=105 MAF, the average spring flow shall be determined by a linear interpolation between 220 kcfs and 260 kcfs. When the January-July volume runoff forecast for The Dalles is >105, the target average spring flow at McNary will be at least 260 kcfs.

See NMFS 1995b for a discussion of the rationale behind these flow objectives.

2. The COE shall spill at the Snake and Columbia River projects in order to increase fish passage efficiency and survivals at the dams.

The COE, during the juvenile spring/summer chinook migration season (April 10 - June 20 in the Snake River and April 20 - June 30 in the Columbia River), shall spill at all projects, including collector projects, to achieve a fish passage efficiency target of 80%, except under the following low flow conditions: During any week in which unregulated weekly average flows at Lower Granite Dam are projected to be less than 100 kcfs, no spill shall occur at Lower Granite Dam; during any week in which unregulated weekly average flows at Lower Granite Dam are projected to be less than 85 kcfs, no spill shall occur at Lower Granite, Little Goose, and Lower Monumental dams, unless the TMT recommends that spill occur. During the fall chinook migration season (June 21 to August 31 in the Snake River and July 1 to August 31 in the Columbia River) the COE shall spill at all non-collector projects to achieve a fish passage efficiency target of 80%.

It is NMFS' view that the best condition for an evaluation of the effects and efficacy of spill to improve inriver survival would be for a single spill regime to prevail throughout the spring migration season. NMFS' first draft of the biological opinion used a volume runoff forecast in the Snake River to trigger spill operations, which would then remain constant during the season. In making recommendations to spill at collector projects when flows are below target levels, the TMT should take into consideration the objective of having a credible evaluation of the spill program. Accordingly, TMT recommendations to spill at the above projects in the Snake and Columbia rivers at flows below the triggers specified should take into account past flow conditions and future flow projections, how close flows are to the trigger levels and how much augmentation is planned, the timing of the juvenile migration, and the need for a credible evaluation. If the use of weekly flow triggers compromises an evaluation, NMFS will consider returning to a volume runoff approach.

During low flow periods, spill at collector projects is reduced or eliminated in order to increase the proportion of fish transported. The discussion under measure 3 explains the rationale for increasing transportation under low flow conditions.

Spill levels calculated to obtain an 80 percent fish passage efficiency are listed below for each lower Snake and lower Columbia River dam. These levels are expressed in percent of instantaneous project flow during the spill period and were calculated with the best available information regarding spring and fall chinook salmon guidance efficiency, spill efficiency, fish passage diel and project operating conditions. Spill periods are 24 hours at Ice Harbor, The Dalles and Bonneville Dams and 12 hours (1800-0600) at all others.

DAM	LGR	LGS	LMN	IHR	MCN	JDA	TDA	BON
% Flow, Spring	80	80	81	27	50	33	64	*
% Flow, Summer	**	**	**	70	**	86	64	*

* An 80% FPE level is not obtainable at Bonneville Dam given a day time spill cap of 75 kcfs and the current low fish guidance efficiency levels. This spill cap (in place to reduce adult fallback) limits obtainable spring FPE to 74% and summer FPE to 59% at 100 percent nighttime spill.

** Spill is not recommended at these projects for summer migrants.

The spill levels necessary to obtain this FPE may be limited by total dissolved gas (TDG) in the river between each project. Specific monitoring sites for the purposes of in-season dissolved gas management should be selected on the basis of data consistency and relationship to fish exposure. Until it can be determined how tailrace monitoring stations relate to the river reaches between monitoring sites and how TDG data collected at these sites relate to fish experience, forebay monitoring data will be used for in-season management. Water quality and other fishery management agencies have recommended that monitoring sites be located below mixing areas, the forebay monitors are the only presently established monitors that consistently provide mixed flow data. Tailrace monitors are of limited usefulness at this time, however, they probably best estimate maximum acute exposure, particularly for adults.

Spill will be reduced as necessary when the 12 hour average TDG concentration exceeds 115% of saturation (or as limited by state water quality standard modifications) at the forebay monitor of any Snake or lower Columbia river dam or at the Camas/Washougal station below Bonneville Dam or another suitable location to measure accurately chronic exposure levels. Spill will also be reduced when 12 hour average TDG levels exceed 120% of saturation (or as limited by state water quality standard modifications) at the tailrace monitor at any Snake or lower Columbia River dams. Average concentrations of dissolved gas will be calculated using the 12 highest hourly measurements per calendar day. The use of 12-hour averages, rather than 24-hour averages, is an attempt to set a more conservative standard, and to relate the measured concentrations of dissolved gas to the 12-hour spill cycles. Spill will also be reduced when instantaneous TDG levels exceed

125% of saturation (or as limited by state water quality standard modifications) for any two hours during the 12 highest hourly measurements per calendar day at any Snake or lower Columbia River monitor.

The intent of these gas caps is to ensure that the long term exposure of adult and juvenile migrants is to TDG levels that do not exceed 115%. NMFS concludes this operation accomplishes that goal for several reasons. Radio telemetry studies indicate that juvenile salmonids tend to move out of tailrace areas within a few hours (Snelling and Schreck unpublished) and that adults tend to move about laterally in tailraces prior to ascending ladders (Johnson et al. 1982, Turner et al. 1983). These movement patterns limit exposure to high spill basin TDG levels. As spilled water moves out of the tailrace the TDG level decreases at some point below the project (depending on ratio of these flows and river topography) because the spilled water mixes with water from the powerhouse. For instance, Blahm (1974) found that, given moderate spill levels, the river was well mixed within 2.5 miles of The Dalles Dam and 15 miles below Bonneville Dam. The requirement that TDG levels in the forebay be limited to 115% will help ensure that areas where migrating juveniles may spend long periods of time do not have TDG levels in excess of 115%. Radio tag studies have indicated that some spring migrating juvenile salmon may be delayed from several hours to several days in these areas (Snelling and Schreck unpublished, D. Rondorf, NBS, February 24, 1995, pers. comm.). Finally, the fact that spill is intermittent at many projects will help limit dissolved gas exposure of fish holding in the forebays and other areas between the projects. This is particularly true for adult migrants.

After reviewing available information on dissolved gas exposure as well as information and recommendations submitted by the parties during the IDFG v. NMFS discussions, NMFS concluded that 115% TDG measured in the forebays was a reasonable interim measure to adopt. Several commenters argued that the Environmental Protection Agency's recommended water quality limit of 110% represented an appropriate level and should not be varied. State and tribal entities developed a risk assessment that suggested that long term exposure to 120% did not pose significant risks to migrating fish and that the benefits of improved dam passage outweighed these minimal risks of TDG exposure at 120%. Still other commenters noted the spill at collector projects reduced the numbers of fish transported and that any risk assessment had to consider the benefits of transportation. The issue of transportation is addressed more fully in measure 3 below.

NMFS concluded that it was appropriate to seek an operation that would result in the EPA criteria of 110% being exceeded primarily because of: 1) the ability of fish in a river environment to compensate hydrostatically for the effects of dissolved gas supersaturation, and 2) the daily fluctuation in levels of dissolved gas throughout most of the river. In a river environment, depth of migration reduces TDG effects on migrants. Each meter of depth provides pressure compensation equal to a 10% reduction in TDG. Shew et al. (Undated) and Turner et al. (1984b) noted through tunnel studies that net entry rates through McNary and Bonneville dam ladder entrance tunnels were highest for the deepest (3.4m) tunnels. Other studies indicate that adult and juvenile salmon tend to spend most of their time at or below one meter of depth (Smith 1974). Blahm (1975) concluded that shallow water tests were "not representative of all river conditions that directly relate to mortality of juvenile salmon and trout in the Columbia River." In deep tank tests, salmonids exposed to 115% TDG levels did not experience significant mortality until exposure time exceeded approximately 60 days (Dawley et al. 1976).

NMFS also concluded that it was not appropriate as an initial interim level to seek an operation that would result in chronic exposure to TDG level of 120%, as recommended by the states and tribes. In general, chronic exposure to TDG levels of 120% with hydrostatic compensation does not cause significant mortality until exposure time exceeds 40 days (Dawley et al. 1976). This is generally more time than it takes Snake River juvenile and adult migrants to travel between Lower Granite and Bonneville dam. Nevertheless, NMFS concluded that the more conservative level of 115% is appropriate because of concerns about the potential sublethal effects of gas bubble disease. The state and tribal report on "Spill and 1995 Risk Management" summarized the studies showing evidence that swimming performance, growth and blood chemistry are affected by high dissolved gas levels. The report correctly states that it is only inferential that these symptoms may result in susceptibility to predation, disease and delay. In fact, studies conducted in 1993 and 1994 by the National Biological Service indicated that juvenile chinook salmon that have been exposed for eight hours to high TDG (and exhibiting microscopic signs of gas bubble disease) are no more vulnerable to northern squawfish predation than control fish that had been held in equilibrated water (Mesa and Warren, in review). Ultimately the analysis in the state and tribal report did not assume any level of mortality as a result of these sublethal effects.

NMFS concludes that the impairments to migrating fish as a result of the sublethal effects of dissolved gas may be sufficiently grave to warrant caution in setting long term exposure levels above 110%. In particular, long term exposure to levels in excess of 110% decrease swimming ability (Dawley and Ebel, 1975); fish stressed with high levels of dissolved gas have been reported to have less swimming stamina (Dawley et al., 1975); and gas bubbles in the lateral line can impair sensory ability. In addition, although fish in deep tank studies are less affected by high levels of TDG than fish in shallow tanks, some mortalities still occur despite a water depth that is apparently adequate for protection. There is no evidence that fish can ’sense" TDG supersaturated water and deliberately sound to compensate.

At specific projects where specific levels of spill, particularly daytime spill have been shown to be detrimental to fish passage, timing and/or amounts of spill may have to be adjusted (for specific details see NMFS 1994b). Spill may also be limited at projects where it can be demonstrated that spill may be detrimental to system spill allocation. One such project is John Day Dam, where very low amounts of spill result in very high TDG levels. These high TDG levels then limit the amount of spill possible at dams downstream. For instance, by reducing spill by 10 to 20 kcfs at John Day Dam, it may be possible to increase spill at The Dalles or Bonneville dams by 20 to 40 kcfs. The exact relationship will need to be developed through in-season spill/TDG testing. The limitation of spill may also apply at The Dalles Dam to minimize the passage of spilled flow and fish over the high predation risk area in the shoals below the dam (see specific details in NMFS (1994b). The details regarding this limitation will be decided in-season through consultation with predation experts and will likely depend on ambient flow and the spill levels obtainable under the TDG limitations. In 1995, spill at Ice Harbor, The Dalles, and John Day Dams may be modified to accommodate research activities if NMFS determines that the spill modifications will not affect the validity of the transport vs. in-river survival study. These spill operations should be treated as interim until the effects of TDG on migrating salmonids are more fully evaluated and until a spill/transport rule curve can be developed. The rationale for flow targets associated with spill at collector projects is related to transportation policy and discussed under measure 3 below.

Migration over the spillways or through the bypass systems are the safest routes of passage at the dams. Injury and mortality can occur through each route of passage (turbines, spillways, ice and trash sluiceways, juvenile fish bypass systems), but loss rates via the spillways and bypass systems are low relative to passage by the turbines. For both spring/summer and fall chinook salmon, mortality of fish passing over the spillways or through the bypass systems generally ranges from 0-3% (Schoeneman et al. 1961; Heinle 1981; Ledgerwood et al. 1990; Raymond and Sims 1980; Iwamoto et al. 1994). Direct turbine mortality can range from 8-19% for yearling chinook salmon and 5-15% for subyearling chinook salmon (Holmes 1952; Long 1968; Ledgerwood et al. 1990; Iwamoto et al. 1994). Values of turbine and spill mortality are not available for sockeye salmon. However, it is reasonable to assume that these values are similar to or greater than values for yearling chinook salmon due to size and timing of migration and due to the greater susceptibility of sockeye to physical injury and mortality in project passage and handling (Gessel et al. 1988; Johnsen et al. 1990; Koski et al. 1990; Parametrix 1990; Hawkes et al. 1991).

This spill program is experimental due to uncertainties about benefits of transportation of smolts relative to in-river migration, as well as uncertainties about the effect of nitrogen supersaturation on free-swimming fish in the river. Gas supersaturation is a negative effect of spill and the precise relationship between spill levels and gas bubble disease in juvenile and adult salmon migrating in the Columbia and Snake Rivers is not known. The spill program will be accompanied by an extensive physical and biological dissolved gas monitoring effort (see measure 16) as well as studies to assess reach survival and to compare survival of transported versus in-river migrants, as well as studies that compare adult returns from transported fish versus fish that migrate in-river under improved in-river migration conditions (i.e., improved flows and improved passage survival at dams through spill). Ideally a spill program, rather than setting a gas cap across all projects, would be based on a project-by-project analysis, with the benefits of spill passage balanced against the risks of gas bubble disease at each project. Such an analysis will require more information about the TDG levels that result at different levels of spill at each project, in relation to spill at other projects, and more information about the lethal and sublethal effects of creating supersaturated conditions through the river.

3. The COE shall transport all fish collected at the lower Snake River collector projects unless the TMT recommends otherwise or transportation operations are out of criteria. Spring migrants collected at McNary Dam should be returned to the river after PIT-tag detection.

As indicated under measure 2, spill will occur at collector projects at specified flow levels, resulting in fewer fish collected for transportation. Chinook salmon smolts collected at the three lower Snake River transport projects should be transported, except that when transportation operations are out of compliance with criteria established in the COE's Juvenile Fish Transportation Plan (e.g., longer holding times or higher densities), fish shall be returned to the river to migrate until operations are within criteria. Because transport-to-control 95% CI values from 1987 and 1988 yearling chinook transportation studies from McNary Dam are wide and values for some groups were less than one, and the number of recoveries from a variety of locations was small, NMFS believes there is sufficient uncertainty regarding the benefits of transported yearling salmon to warrant suspending transport from that site during the spring. Spillway passage and return to the river of collected fish at McNary Dam should continue until subyearling chinook predominate the daily total chinook collection for three consecutive days. The TMT may recommend that fish be returned to the river to migrate under other circumstances if credible evidence is presented that in-river migration will be beneficial. Section IV.A.4 reviews available information regarding both the negative and positive effects of transportation. NMFS' view has been that available empirical data indicate that transportation benefits Snake River spring/summer chinook and is likely to benefit Snake River sockeye and fall chinook. Accordingly, NMFS has supported transportation of Snake River salmonids under most conditions. State and tribal analysis, on the other hand, concludes that there is substantial delayed mortality associated with transportation. This mortality is reflected in the FLUSH modeling and results in low population projections for recovery strategies that rely on transportation.

Consistent with this view, most comments received from states and tribes during the IDFG v. NMFS discussions favored decreased reliance on transportation of Snake River juvenile migrants. This position was supported by the Power Planning Council's recently adopted salmon amendments. Conversely, other regional experts, including NMFS' Recovery Team, supported a strategy that relies heavily on transportation.

Based on the information available, NMFS continues to conclude that transportation has demonstrated benefits for Snake River spring/summer chinook and is likely to benefit Snake River fall chinook and sockeye salmon. Accordingly, NMFS has concluded that it is appropriate to continue to rely on transportation as a major means to mitigate the adverse impacts of the FCRPS. At the same time, NMFS recognizes the validity of the concerns raised by the states, tribes and others both about the absolute benefits of transportation and of its ultimate efficacy as a recovery tool. This position is consistent with the recommendations of the peer review panel that "juvenile transport appears to have the potential to contribute to recovery of listed stocks," but that "[i]ts use should be experimental in the sense that it should be continually monitored and evaluated, with an eye to quantifying the factors that determine both transport and river survivals (Mundy et al. 1994, p. 95-C).

The spill program identified in measure 2 is intended to address state and tribal concerns and those expressed in the peer review. It serves the dual purpose of increasing the numbers of fish left to migrate inriver while at the same time improving survivals of those fish left in the river by increasing spill. This operation should create an opportunity for a transport evaluation that compares adult returns from transported fish and fish migrating in improved inriver conditions.

Because it is likely that the benefits of transportation increase as flow decreases (Mundy et al. 1994), spill is limited to those years when in-river migration conditions (primarily flows) are likely to limit the risk to smolts left to migrate in-river. NMFS has identified an average flow of 85 kcfs in the Snake River during the migration season as the initial flow level to implement spill at collector dams, thereby increasing the proportion of migrants that will migrate down the river rather than be transported. A flow of 85 kcfs corresponds to the flow objective established in paragraph 1 for desirable in-river conditions for spring/summer chinook. The proportion of fish left to migrate in-river is increased when flows exceed 100 kcfs by adding spill at Lower Granite Dam. A flow of 100 kcfs corresponds to the prior "spread-the-risk" policy developed by the fishery agencies and tribes as the appropriate level of flow at which to decrease transportation. It also corresponds to the top of the sliding scale established by NMFS as a flow objective for the Snake River. This operation is expected to result in approximately 74% of spring/summer chinook juveniles arriving at Lower Granite Dam being transported at flows over 85 kcfs and 56% being transported at flows over 100 kcfs.

Spill is not recommended at transport projects during the fall chinook migration period because low flow conditions result in slow travel time, elevated temperatures, and increased predation for migrating juvenile salmon. Fish collection efficiencies at the dams are believed to be lower for subyearling chinook than for yearlings, and as a result more subyearlings will pass through turbines without spill. It is nevertheless NMFS' judgment that survival of fall chinook salmon smolts will be sufficiently higher if transported, rather than left in the river to migrate, to justify not spilling. (See the discussion of benefits of transportation in Section IV.A.4.a.)

The spill and transportation operations are intended to be interim. Ideally these interconnected programs would be based on a rule curve that establishes the relationship between flow conditions, in-river survivals, and the relative benefits of transportation. Work was begun on such a rule curve, but was not completed in time for issuance of this Biological Opinion. The NMFS will establish a workgroup to review information obtained from the 1995 spill program and other information and make recommendations regarding the appropriate levels of spill and transportation in future years.

4. The COE shall operate lower Snake River pools within one foot of minimum operating pool (MOP).

Operate lower Snake River reservoirs at MOP from April 10 until adult fall chinook salmon begin entering the lower Snake River (late August), then fill the lower three pools to allow adult fishways to operate more nearly in criteria. Fill the Lower Granite pool after November 15, after the end of the adult fall chinook passage season. Pools may be operated at elevations higher than within one foot of MOP for approved research.

Adult fishways at the upper three Snake River projects require greater tailwater elevations than MOP to provide maximum entrance gate depths in adult fishways during low flows; however, higher flows with reservoirs at MOP will increase tailwater elevations, thus increasing entrance depths during the spring.

Drawdown to MOP reduces the cross-sectional area of the reservoir, increasing water velocity for a given flow. Since juvenile migrants travel faster with increased water velocities (Sims et al. 1983; Berggren and Filardo 1993), drawdown to MOP is expected to provide faster emigration and improved survival through the pools (NMFS 1995b).

5. The COE shall operate John Day pool within a one-and-a-half foot range of minimum irrigation pool from April 20 to September 30, 1995. In addition, the COE will continue planning, design and construction to continuously operate John Day pool near MOP by March 1996 and investigate feasibility to operate John Day pool to spillway crest.

Operation at MOP from March through October will be within a three foot range. Drawdown reduces the cross-sectional area of the reservoir, increasing water velocity for a given flow. Since juvenile migrants travel faster with increased water velocities (Sims et al. 1983; Berggren and Filardo 1993), drawdown to MOP is expected to provide faster emigration and improved survival through the pool (NMFS 1995b).

Concerns have been raised that lowering John Day reservoir to minimum operating pool on a seasonal basis may have adverse effects on wildlife and other fish populations. Accordingly, John Day pool shall be operated at near-minimum operating pool on a year-round basis (i.e., no more than three foot fluctuations March through October and no more than five foot fluctuations November through February). The BPA should also investigate the use of nearshore and shallow habitat by juvenile salmon in the John Day reservoir.

Operation of John Day reservoir to minimum operating pool should occur as soon as possible after March 1996 but only after appropriate mitigation measures have been assured. Concerns have been raised that operation at near-minimum operating pool will adversely affect the operation of irrigation pumps that draw water from the John Day pool. The extension of pumping facilities should be undertaken immediately by the fastest means available. MOP operations will also require fish and wildlife mitigation actions.

With respect to a spillway crest drawdown of John Day reservoir, NMFS and COE will develop a study and implementation schedule that addresses other improvements being considered at John Day such as surface collectors, screens, and dissolved gas abatement measures.

The drawdown of John Day pool has been particularly controversial, with the Recovery Team and others recommending against it and state, tribal, environmental interests and the Power Planning Council supporting it. NMFS has included this provision in its reasonable and prudent alternative because it is a measure that provides travel time benefits through a reservoir that is believed to have among the highest predation levels in the river. According to COE analysis, a drawdown from MIP to MOP of John Day will decrease water particle travel time (WPTT) through the reservoir of between a half and one and a half days (Harza 1994). According to analysis conducted by the Council, this benefit is equivalent, for Snake River migrants, to obtaining an additional 3 MAF of augmentation volume in the upper Columbia. While this benefit may appear small, NMFS concludes it is an important component in the overall effort to improve fish travel time through the Columbia River, particularly in light of the difficulty and expense of obtaining equivalent volumes for flow augmentation from the upper Columbia.

Drawdown of John Day to MOP would also increase the ability of the reservoir to provide flood control additional to that at Grand Coulee. John Day is currently used to provide flood control in the Columbia, with storage available between full pool and MIP of approximately 150,000 acre-feet. Drawing John Day down to MOP provides and additional 350,000 acre-feet of storage. NMFS has also concluded that it is most prudent for a MOP drawdown of John Day to be permanent, rather than have dramatic fluctuations in water levels. The COE concluded, and NMFS agrees, that permanent drawdown would allow for a stable riparian land base for wildlife habitat development.

6. The COE and BPA shall operate turbines within one percent of peak efficiency during the juvenile and adult migration seasons (March 15 through October 31 in the Columbia River and March 15 through November 30 in the Snake River) as indicated in updated load shaping guidelines contained in the FPP. These guidelines will be updated through the consultation process with NMFS prior to March 15, 1995.

Operating turbines at peak efficiency provides the highest survival of chinook salmon, sockeye salmon, and other anadromous species during passage through a turbine (Bell et al. 1981; Eicher 1987).

7. The COE shall maintain fish facilities within criteria identified in the COE Fish Passage Plan (FPP).

Insufficient ladder entrance water depth and insufficient entrance attraction velocity are factors that negatively affect adult fish passage (Bell 1991). Maintaining fishways within optimum criteria for passage is likely to reduce dam passage delays for migrating salmon. Adult fish passage facilities at Snake River projects fail to operate within optimum criteria a substantial portion of the time during the adult migration season due to MOP operations (COE 1994). Monitoring adult fishways frequently and improving the maintenance and repair of fishway components such as pumps, gear boxes, diffuser valves, entrance gate controls, etc. are expected to improve system operational reliability. Facilities should be inspected daily and maintenance and repairs should be completed as quickly as possible. Upgrading existing adult fish passage facilities, including (1) automation of control systems; (2) placement of staff gauges (for determining water elevations) in areas that are accessible for both cleaning and reading, and (3) providing velocity meters in areas of known low velocity in the collection channels will also aid the monitoring effort and contribute to maintenance of optimum criteria.

Pending available funding, a NMFS inspection biologist will be assigned for each COE district. The NMFS biologists will inspect juvenile and adult fish facilities, maintenance activities which affect fish or fishways, fish monitoring activities and any other facilities, activities or equipment which may affect fish passage and survival at each COE project. These NMFS inspections will complement more frequent inspections by COE biologists and operators.

Additional evaluation should include observation of juvenile migrant condition through periodic sampling and review of weekly COE reports summarizing the operation of adult and juvenile fish facilities.

8. The COE shall implement measures to reduce adult fallback mortality, including installing extended length screens and extending the period during which the juvenile bypass system is in operation.

Fish mortality in turbines is believed to occur by direct strike, shear, and passage through low pressure areas. Screens are the most effective method of preventing fish from entering turbine intakes (Bell 1991). Peak turbine efficiency provides the lowest fish mortality (Bell et al. 1981; Eicher et al. 1987). Extending juvenile bypass system operation throughout the adult migration (through December 15) and installing extended-length screens (pending evaluation and rectification of descaling effects on juveniles) will reduce the number of adult chinook and sockeye salmon fallbacks that pass through turbines. This measure would also benefit other anadromous species. Priority units will be left screened during this period to the extent practicable, and screens from nonpriority units will only be removed when necessary to begin maintenance. If units are required for operation during this period, and are unscreened, they will be operated on a last on/first off basis.

9. The COE shall begin modifications to enlarge transport barge exits by 1996, with completion by the spring of 1997.

Modifications would reduce fish crowding and agitation stress upon release. Release of juvenile steelhead with additional levels of stress has been shown to result in increased holding and increased predation mortality (Poe and Gadomski 1994).

Immediate Research, Evaluation and Engineering Studies to Improve Survivals in the Intermediate and Long Term

10. The COE shall complete necessary feasibility, design and engineering work to allow drawdown of Snake River reservoirs to begin by 2000.

As illustrated in figure one, page ??, by mid-1996 the COE will complete an interim report which evaluates the feasibility of and analyzes the information regarding drawdown to natural river, spillway crest, and surface collection. Utilizing this information the COE and NMFS will decide on which drawdown option to carry forward to the engineering and design (E&D) stage, along with surface collection. E&D work on the drawdown alternative chosen and surface collection should be completed by mid-1998, unless NMFS and COE have agreed to a different E&D program with a different scope or on a different time frame. At that time, the COE will proceed with selection of the final plan, completion of the feasibility analysis, final NEPA documentation, and seek congressional authorization in order to ensure that drawdown and/or surface collector implementation may begin by 2000.

In order to expedite engineering and design work and lower costs NMFS suggests that the COE seek bids and utilize independent contractors whenever practical. Also, NMFS recognizes that the COE routinely uses independent contractors to perform and review design and engineering work. NMFS supports and encourages this approach for this task.

The NMFS recognizes there is a practical limit to the use of reservoir storage to achieve target flows for improved survival of migrating salmon, particularly in the Snake River, and that the region must continue to explore aggressively and implement additional velocity measures to restore the inriver migratory conditions necessary to achieve rebuilding of listed populations, to reduce reliance on transportation of juvenile salmon, and to increase other salmon runs in the Basin. Accordingly, the COE and BPA shall, in coordination with NMFS, the fishery agencies and tribes, accelerate as a high priority the necessary evaluations and preparations for reservoir drawdowns on the lower Snake River to spillway crest or natural river levels.

Implementation of either natural river or spillway crest drawdown will take extensive planning, design, and construction time. If, after an interim operation period, it is determined that one of these drawdown alternatives is the only option for recovering Snake River salmon, interim planning must have occurred to achieve the drawdown condition in time to affect recovery. Hence, design and engineering, feasibility evaluation, NEPA compliance, and congressional authorization are to proceed in the interim.

Slow passage through reservoirs increases exposure time of juvenile chinook and sockeye salmon (as well as other anadromous species) to predation, to higher temperatures (which increase the predation rate and susceptibility to disease) and to other water quality problems. Turbine mortality has been clearly documented (Iwamoto et al. 1994; Holmes 1952; Shoeneman et al. 1961), as well as lower rates of mortality for fish passing via spillways and bypasses (Ledgerwood et al. 1990; Shoeneman et al. 1961; Heinle 1981). Decreased travel time associated with drawdown is expected to result in increased survival of juveniles through reservoirs. Natural river drawdown would eliminate mortalities associated with reservoir passage as well a with dam passage (although there would still likely be mortalities associated with passage through the free flowing river). Intermediate level drawdowns, such as spillway crest, will likely decrease juvenile travel time to some extent due to reduced reservoir cross section, however, passage at the dam would still be of concern for both juveniles and adults (NMFS 1995c).

Reservoir drawdown must be evaluated in a sequential, scientific manner. The first step must be to collect baseline survival data for juveniles as they migrate through the present reservoirs and dams on the lower Snake River. These baseline estimates would increase the scientific knowledge base of the relative importance of all factors affecting juvenile survival. This information will help to determine the benefits achievable through drawdown.

The feasibility evaluations and NEPA documentation should address potential adverse effects associated with either drawdown alternative, such as NMFS' concern with juvenile and adult passage at the dams with intermediate level drawdowns, or sediment dispersal, predation, and other ecological impacts to juveniles during passage under drawdown conditions.

The state fisheries agencies and tribes, as well as the Power Planning Council, recommend immediate drawdown of Snake River reservoirs to near spillway crest, beginning with Lower Granite Dam and proceeding to Little Goose. NMFS has not chosen this option at this time because of the concerns about passage and other problems associated with a spillway crest operations and because of concerns about the ability of a spillway crest drawdown to achieve meaningful biological benefits. NMFS' concerns about passage problems are detailed in NMFS (1995c) and include such things as dewatering of juvenile bypass and collection facilities, gatewell entrainment and injury, impaired turbine efficiency, dewatering of adult fish ladders, likely poor performance of surface collectors due to decreased distance between the collectors and turbine intakes, and riparian impacts.

NMFS is also concerned about whether the potential benefits of either a spillway crest or natural river drawdown are sufficient to obtain survival improvements that will contribute adequately to the recovery of listed stocks, or that will be greater than survivals obtainable through transportation. Generally the ELCM modeling shows the greater likelihood of achieving survival and recovery goals. The achievement of these goals, however, depends upon the assumption that delayed mortality of transported juveniles approaches 50 percent. If that assumption is wrong, drawdowns could be entirely the wrong strategy, especially spillway crest drawdown. For this reason, NMFS concludes it is reasonable to first test whether there is likely delayed mortality through transport evaluation and reach survival studies.

The approach outlined here is consistent with that recommended by the independent engineers' review of Phase I of the COE's System Configuration Study (Harza 1994). In its report, Harza concluded:

> Before opting for the natural river alternative, the Committee should consider drawdown to be a two-step decision making process. First, Phase II studies on drawdown should be continued to develop preliminary designs for basic building blocks of drawdown . . . . Concurrently, a prototype surface-oriented smolt collection system should be designed, constructed, and tested at Lower Granite Dam. Biological testing would include monitoring of smolt travel time through the reservoir and fish guidance efficiency of

> the collector. If the surface collector failed to improve smolt passage conditions sufficiently to meet regional expectations, the next step would be to shift attention back to the remaining drawdown alternatives. (Harza, p. 23.)

11. The COE shall investigate the application of surface collection technology at lower Snake and Columbia River projects. Testing will begin at Ice Harbor and The Dalles Dams in 1995. Prototype surface collectors should be designed and tested at Lower Granite and The Dalles Dams by June 1996. These tests should include evaluations of surface collection at powerhouses and spillways to determine the effectiveness and safety in passing juveniles.

The COE will investigate the application of surface collection passage systems at the lower Snake and Columbia River hydropower project powerhouses and spillways to determine the effectiveness and safety of these systems in passing juvenile salmon. The evaluation of surface collection is an integral component of the decision path for the lower Snake River hydropower system, which is detailed in Figure One, and explained in the preceding measure. Testing is scheduled to begin in Spring 1995 at Ice Harbor, and Summer 1995 at The Dalles Dams, and will continue at The Dalles Dam in 1996. A prototype surface collector will be designed and tested at the Lower Granite Dam powerhouse and spillway in 1996. If testing in 1995 and 1996 indicates that surface collection is effective at conventional powerhouses, the COE will expedite scheduling to begin testing at John Day powerhouse in 1997 or as soon as possible. NMFS will work closely with the COE in a coordinated manner to review and provide input to all surface bypass investigations.

12. The COE shall begin investigations to improve FGE at the Bonneville first powerhouse.

Subyearling chinook salmon guidance at the first powerhouse during mid-summer averaged 11.0% in 1988 (Gessel et al. 1989) and 4.4% in 1989 (Gessel et al. 1990). Recent yearling chinook guidance averaged 31.7 to 46.5% (Monk et al. 1992). Turbine mortality can range from 11-15% for subyearling chinook salmon (Holmes 1952; Shoenenan et al. 1961) and 8-19% for yearlings (Iwamoto et al. 1994; Long 1968). Improvement in guidance is needed to increase survival of juvenile migrants passing Bonneville Dam.

13. The BPA, COE and BOR shall participate in a coordinated effort with NMFS, ISP, NPPC, Hydropower Management Work Group, and states and tribes to develop a comprehensive monitoring, evaluation and research program.

The dramatically different approaches to Snake and Columbia River salmon recovery are based on different beliefs about what happens to fish in the system. These different views are summarized elsewhere in this document and are reflected in the regional life cycle models. Without a comprehensive program of monitoring, evaluation and research, it is unlikely that these differences will ever be resolved or that we will have information that will lead to recovery.

Such a program should first seek to identify the major and subsidiary hypotheses underlying assumptions about the causes of decline and impediments to recovery of Columbia Basin salmonids. These should be in the form of alternative testable hypotheses. The program should then include the research that can be performed to test these hypotheses, as well as the monitoring, evaluations and analyses that can supplement the research. This approach was taken by the Council in 1994 when it developed flow and transportation hypotheses.

The NMFS' Recovery Plan for listed Snake River salmon establishes a regional structure to manage the recovery of these stocks which can be used for purposes of overseeing this program. The initial steps, however, can be undertaken immediately. The NMFS intends to begin immediately working with regional experts and managers to develop this program. Monitoring, evaluation and research programs shall include the following:

a. The existing smolt monitoring program coordinated by the Fish Passage Center. Monitoring for fish condition is necessary in order to detect and rectify juvenile fish passage facility problems that can descale, injure or kill fish. Sampling capability is also required for approved monitoring programs and research designated in this biological opinion.

b. The BPA shall proceed with evaluation of whether the number and timing of migrating juvenile salmonids affect available prey resources in the Columbia River and its estuary. Simenstad et al. (1982) stated that massive hatchery releases of salmonid smolts may deplete estuarine food resources. This potential consequence could lead to reduced ocean survival of listed salmon. This was identified as a possible problem in the Columbia River estuary (Bottom and Jones 1990). Muir (1990) found the numbers of invertebrate drift in the Columbia River were low in early April when many salmonid hatcheries release their fish.

c. The BPA, BOR, COE shall investigate the relationship between the amount and timing of Columbia River flows and ocean survival of salmonids. Francis et al. (1989) observed that timing and magnitude of the Columbia River peak flow and the resulting structure of its plume may have major effects upon Columbia River salmonid production. The Fraser River plume, which is similar to the Columbia River plume, has enhanced concentrations of nutrients, zooplankton, and salmon prey compared to adjacent marine waters (St. John et al. 1992).

d. The BPA, COE and BOR shall cooperate in investigations of the relationship between fluctuations in estuarine and ocean environment and salmon abundance. Natural mortality in estuarine and ocean environments cannot be predicted with any precision because ecological relationships and stochastic perturbations (e.g., El Niño) are poorly understood. This information is crucial to better defining human induced mortality and appropriate resource management.

e. The BPA, COE and BOR shall cooperate in investigations of environmental requirements of juvenile salmonids in the estuary and nearshore ocean. Environmental conditions in the Columbia River estuary and nearshore ocean environments are factors that influence survival of juvenile salmonids. It is vital to determine what these environmental conditions are and how they interact to affect natural survival and stock distribution in the ocean, how they vary from year to year, and how survival and distribution relate to measurable parameters of the ocean environment (e.g., temperature, upwelling, etc.).

f. The BPA shall evaluate juvenile survival during downstream migration and desired levels of flow augmentation. The NMFS, in cooperation with other agencies and entities, shall formulate long-range survival studies to determine within-year and between-year survivals of smolts migrating through reservoirs and past dams with various flows, spills, and bypass configurations. Studies will relate survival to varying river flows, spills, and dam operations. As an offshoot of the research, studies will be designed to update or confirm relationships of migration rates of fish to flow in the river. Further, where feasible, researchers will determine relationships of fish survival to migrational timing.

g. The NMFS, in consultation with BPA, COE, BOR and state agencies and tribes, shall design a study to evaluate the effectiveness of "pulsing" flows for improving in-river survival of smolts. Collection at dams of juvenile, migrating salmon, particularly yearlings, has been shown to increase with an increase in project flows, thereby decreasing travel time (Achord et al. 1995a, 1995b). However, fish travel time vs flow relationships through multiple dams and reservoirs indicate that pulsing of flows may result in increased average reach travel times for juvenile salmon when compared to steady flows (the decrease in flows between pulsing may increase fish travel time more than an increase in flows during pulsing decreases fish travel time) (Figure 22, FPC 1988). Potential, overall survival benefits to juvenile migrants from pulsing flows is unknown. The BPA, COE and BOR should cooperate in carrying out such studies.

h. The BPA shall investigate the effects of the intensified competition for food resulting from the introduction of non-native species and production of hatchery fish in the Columbia River Basin. American shad were introduced into the Columbia River in the 19th century. Dams have inundated natural barriers and allowed shad to expand their range into the mid-Columbia and Snake Rivers (Bevan et al. 1994). The diet of juvenile shad may overlap with that of juvenile salmon, and adult shad may prey upon juvenile salmon (Wendler 1967 in Bevan et al. 1994; Miller 1994 in Bevan et al. 1994; McCabe et al. in Bevan et al. 1994). Hatchery-produced salmonids compete for food with naturally-produced fish, and may serve to bolster predator populations by providing a food source (Bevan et al. 1994). Alternatively, hatchery-produced salmonids may also buffer predation because predators are opportunistic and may select weaker hatchery fish over wild fish. Juvenile shad sometimes disrupt the collection and transportation of juvenile salmonids because of their overwhelming numbers (D. Hurson, fishery biologist, COE, November 9, 1994, pers. comm.). Adult shad may also delay the passage of adult salmon through fishways at dams (Chapman et al. 1991 in Bevan et al. 1994).

14. The BPA shall continue studies of predator control.

Northern squawfish, smallmouth bass, channel catfish, and walleye are important predators of juvenile salmon (Poe et al. 1991; Tabor et al. 1993). Common mergansers, gulls, terns and other birds also consume juvenile salmonids (Meacham and Clark 1979 in Bevan et al. 1994; Ruggerone 1986 in Bevan et al. 1994; Bevan et al. 1994; Wood 1987). Predator control efforts to date have focused on removing northern squawfish from the Snake and Columbia Rivers, evaluating the behavior and distribution of predators in dam tailrace areas, and limiting avian predation by stringing lines across tailrace areas where juvenile salmonids that may be disoriented from dam passage are vulnerable.

To date there is no indication that squawfish removal efforts have resulted in decreased mortality of juvenile salmon migrants. The effects of squawfish removal, including possible compensation by other predatory fish, should be thoroughly analyzed. The effects of predation by other fish and by birds at dams also need to be examined.

15. The COE shall proceed with studies that will result in improvements in fish passage at mainstem dams to support salmon smolt-to-adult survival ratios that foster long-term population growth. The interim performance objective for these bypass

improvements is an 80% fish passage efficiency and a 95% passage survival at each dam.

The NMFS and other fishery agencies should explore the feasibility and conduct, where appropriate, laboratory and field research to develop new means to collect and/or bypass juvenile migrants so as to avoid turbine related mortality at dams. Studies shall include but not be limited to the following:

1. A re-evaluation of existing smolt bypass systems.

2. Evaluation of new or modified juvenile fish bypass systems at dams to ensure that they function properly.

3. Laboratory and field studies to develop new means to collect and/or bypass juvenile migrants so as to avoid turbine related mortality at dams. These efforts might involve development of upstream collectors not directly connected with dams. Studies should consider the use of extended-turbine-intake screens, surface collection facilities (see #11), sonic or other behavioral modifying guidance of smolts into bypass routes, and state-of-art delivery systems from forebay to tailrace.

4. Studies to develop better methods for counting the number of fish in the bypass and holding systems at the dams.

At dams, injury and mortality can occur through all routes of passage (turbines, spillways, ice and trash sluiceways, juvenile bypass systems, etc.). However, numerous studies have documented that mortality through turbines is usually higher than other routes of passage. Screens that guide juvenile fish into bypass systems away from turbine passage have been installed at seven of the eight mainstem dams that Snake River salmon must pass. Also, limited spill is provided at dams without screened bypass systems, or with inadequate bypass systems, to provide an alternative passage route and decrease the number of juveniles passing through turbines.

16. The BPA, COE, and BOR shall participate in the development and implementation of a monitoring and evaluation program to investigate the effects of dissolved gas supersaturation. This program will include the physical and biological monitoring components of a dissolved gas monitoring plan developed by the NMFS in consultation with the COE, BPA, BOR, FWS, and NBS prior to March 10, 1995.

At a minimum, the physical monitoring components of this plan will include placement of physical dissolved gas monitors in the tailraces and forebays of all Lower Snake and lower Columbia

River dams, and daily recording of dissolved gas data on the CROHMS database. This program will also include a quality assurance and control component including backup monitors at as many locations as possible, weekly calibration of dissolved gas monitoring equipment, an error checking, correcting and recording function for CROHMS data and comprehensive transect measurements of dissolved gas between each project and below Bonneville Dam.

At a minimum, the biological monitoring components will include smolt monitoring at all smolt monitoring locations by the NBS, smolt monitoring at selected forebay locations, adult monitoring at Bonneville and Lower Granite dams, river reach sampling and *in situ* bioassays below Ice Harbor and Bonneville dams, salmonid distribution monitoring and daily data collection and reporting.

NMFS and EPA will establish a technical work group comprised of technical representatives from all the state and federal and tribal governments that share responsibility for managing water quality and fisheries in the Pacific Northwest to prioritize long- and short-term research and provide a forum for the technical-level discussion of all aspects of dissolved gas monitoring and evaluation.

This program will also include development of methods to avoid load distribution situations that result in excessive spill levels and resultant dissolved gas levels in excess of seasonal dissolved gas limits. In 1993, unexpected high runoff conditions and low load demand combined to create high spill levels at lower Snake River dams resulting in peak hourly dissolved gas levels in excess of 140%.

Dissolved gas supersaturation caused by large volumes of water spilling over dams can result in injury or mortality for juvenile salmon. Since the 1960s, increased hydraulic capacity at powerhouses of mainstem projects, increased storage of water, and structural modification to spillways have substantially reduced this problem. However, high levels of dissolved gas have been measured under certain river conditions in recent years. Evidence of significant injury or mortality of large numbers of fish has been lacking for both adult and juvenile fish. Studies should be conducted to determine the magnitude of mortality associated with dissolved gas supersaturation under conditions fish presently encounter in the migration corridor such as determining the mortalities to in-river juvenile salmon smolts and resident species under various proposed levels of atmospheric gas supersaturation limits in the Snake and Columbia Rivers. Studies should include evaluation of sublethal effects, which can compromise the ability of smolts to survive in the lower river and estuary.

17. The BPA shall participate with NMFS in activities to coordinate the regional passage and life cycle models and to test the hypotheses underlying those models.

In 1994 NMFS and BPA jointly funded a program to coordinate and review the different regional life cycle models. This effort should continue in 1995 and beyond, but the emphasis should shift to analyses that test the different assumption underlying the models rather than refine our understanding of how the models are different. NMFS concludes the recommendation of the review group to conduct a Bayesian analysis should be pursued (Barnthouse et al., 1994).

Such an analysis could be pursued using the services of the existing review group and the existing facilitator. The current modeling technical group (ANCOOR) could provide technical support to the effort, but the analysis itself should be done by an independent contractor. NMFS and BPA should continue to fund this effort.

<u>Intermediate Term Actions to Improve Survivals</u>

18. The COE shall develop and implement a gas abatement program at all projects with appropriate structural modifications. The program shall include stilling basin and spillway modifications to reduce gas supersaturation at Ice Harbor and John Day Dams as soon as possible, contingent on the results of facility gas abatement evaluations in 1995 and 1996. The COE shall investigate operational methods that help reduce dissolved gas levels (such as spill bay discharge levels and patterns) in 1995 and implement the results in 1996.

Nitrogen gas supersaturation caused by the entrainment of gases from the deep plunging of water spilled at dams can cause passage delays, blindness, and mortality in adult migrants (Bjornn and Peery 1992). Reduction in supersaturated gas levels by modifying spillways and stilling basins will increase passage success and reduce mortality. Shifting of generation to meet power system demands is a viable means to address high dissolved gas levels from involuntary spill.

Spill deflectors (flip lips) are present on five of the eight mainstem federal dams on the Columbia and Snake Rivers and are important in reducing levels of gas saturation. Modifications to stilling basins at other mainstem dams may also help to reduce gas levels during periods of spill. These gas abatement improvements should be designed to be effective under a wide range of flow and operational variables. See action 2 (spill) for discussion of spill benefits for juvenile fish.

19. The COE shall continue the scheduled installation of extended-length screens at Lower Granite and Little Goose dams for the 1996 migration season, and at McNary Dam for the 1997 season, and later potential installation at Lower Monumental and Ice Harbor to improve survival of summer migrants. Conduct scheduled prototype testing of extended length screens and prototype vertical barrier screens at Little Goose and Lower Granite Dams in 1995.

Extended-length screens and structural improvements to improve bulkhead gatewell hydraulics, should be programmed at Ice Harbor and Lower Monumental contingent upon results of prototype testing of screens at Little Goose and Lower Granite Dams, and results of surface collection prototype tests.

20. The COE shall identify a preferred plan for improvements to the Lower Granite juvenile facility by August 1995. Implement by 1997 or as soon as possible thereafter, pending results of surface collection evaluations at Lower Granite in 1996.

The COE should coordinate closely with NMFS and others throughout this plan development. At a minimum, improvements for consideration should include elimination of the existing downwell, addition of a primary dewatering structure, open-channel fish transportation flume, capability for separation of juvenile fish by size, and improved direct-loading. Design through plans and specifications for improvements should be completed so that construction may begin promptly pending results of prototype surface collection tests in 1995 and 1996.

21. The COE, pending evaluation that includes an analysis and determination of descaling incidence and the results of screen prototype tests, and surface collection, shall install extended length screens at John Day Dam by April 1998.

Fish guidance efficiency (FGE) for subyearling chinook salmon at John Day Dam is approximately 35% (Brege et al. 1987). The FGE for extended length screens was substantially higher than for standard length screens during testing at McNary Dam (Brege et al. 1992; McComas et al. 1993). Higher FGE will improve survival of downstream migrants at John Day Dam by guiding additional juvenile migrants out of turbines.

22. The COE and BPA shall expedite installation of new juvenile sampling facilities, including PIT-tag detectors, to be completed as soon as possible, but not later than 1997 at John Day Dam and by 1999 at Bonneville Dam. The BPA shall investigate interim PIT-tag detectors for installation at Bonneville Dam by spring 1997.

New facilities are needed to provide periodic, representative fish sampling capability for prevention of fish injury during passage through juvenile fish passage facilities. New facilities are also needed to incorporate PIT-tag capability, which will provide the ability to evaluate recovery actions. Evaluations of in-river survivals and actions to improve those survivals are hindered by the lack of PIT tag detection capability in the lower Columbia River. The COE and NMFS had developed a program to install PIT-tag detectors at Bonneville Dam by 1998. That plan, however, involved use of an interim bypass outfall. The NMFS concluded that such an outfall would create worse conditions than those that exist now. The NMFS, therefore, agreed to a schedule for an entire new juvenile bypass by 1999. Unfortunately, this delays COE's ability to have full-scale PIT-tag detectors in place by 1998.

23. The COE shall relocate the permanent downstream migrant outfalls at Bonneville Dam by spring 1999.

Passage survival tests at Bonneville Dam indicate that tailrace predation may be substantial (Ledgerwood et al. 1990). Northern squawfish are major predators of juvenile salmonids in the Columbia River Basin. Results of swimming performance tests indicate that high water velocities may exclude or reduce predation by northern squawfish due to their inability to hold position (Mesa and Olson 1993). Relocating downstream migrant outfalls to areas of higher water velocity and away from shoreline areas where squawfish may take refuge is anticipated to increase the survival of juvenile migrants.

24. The COE shall continue comprehensive design of the conventional juvenile bypass system (submerged screens) at The Dalles Dam and complete installation by 1999, depending on the results of prototype surface collection testing in 1995.

Direct turbine mortality can range from 8-19% for yearling chinook salmon and 5-15% for subyearling chinook salmon (Holmes 1952; Long 1968; Ledgerwood et al. 1990; Iwamoto et al. 1994). Juvenile bypass mortality, excluding outfall mortality, generally ranges from <1-4% (Ceballos et al. 1993). The mortality of juvenile migrants is expected to be reduced at The Dalles Dam by guiding juvenile migrants out of turbines. Following prototype testing, a decision should be made in 1995 as to whether to continue with the development of a surface collection system and/or to proceed with the design and installation of submerged screens.

25. The COE, in consultation with NMFS, shall determine in 1995 the number and size of additional juvenile transportation barges needed to provide direct-loading capability from all four transport dams with an ongoing spill program and purchase new

barges annually, beginning with a minimum of two new barges in 1997, with phase in to be completed by 1999.

First priority should be on implementing capability for direct-loading from Lower Granite and Little Goose Dams. Additional barges are required for direct-loading of juvenile fish at transportation projects. Direct-loading removes the stress induced by crowding and loading fish from raceways.

26. A process shall be established to review progress on planning/engineering studies, and/or collection of research data, and make appropriate modifications to the measure or schedule where a measure is contingent upon completion of these studies. The process shall include periodic meetings between the appropriate action agency and NMFS, and would document any change in schedule or measure based upon available scientific information.

27. The BPA, COE, and BOR shall each review any prospective agreement, plan, or contract ("prospective agreement") used to plan for the operation of or actually operate the FCRPS to implement the reasonable and prudent alternative actions, reasonable and prudent measures, and terms and conditions ("actions or measures") set forth in this opinion. If a proposed agreement has provisions that go beyond implementing the actions or measures, the agency proposing to make such an agreement shall keep NMFS informed as it determines whether the proposed agreement "may affect" listed Snake River salmon in a manner or to an extent not considered in this opinion. (See discussion in Part IX below.) If so, the action agency shall consult with NMFS (possibly by reinitiating this consultation) on the proposed agreement.

B. Analysis of Why Adoption of the Reasonable and Prudent Alternative Is Not Likely to Jeopardize the Listed Species

Section I.B and the introduction to Section VII describe the analysis NMFS uses to determine whether biological requirements of listed species are likely to be met. Section VII also discusses the analytical tools NMFS will use to determine whether an action jeopardizes the continued existence of listed species, including the passage and life cycle models and NMFS' view of how they may best be used. NMFS concludes that the reasonable and prudent alternative does not jeopardize the continued existence of listed Snake River stocks.

The reasonable and prudent alternative establishes an interim operation during which conditions are improved immediately for fish, alternative long term paths are established for major reconfigurations of the hydropower dams, and intensive experimentation, monitoring and evaluation are to occur. The long term alternatives include: Option 1 - implementation of passage improvements at dams, such as surface collectors, that significantly improve bypass and/or collection efficiency; Option 2 - implementation of a spillway crest drawdown at the Snake River projects; Option 3 - implementation of a natural river drawdown at the Snake River projects.

The reasonable and prudent alternative aggressively pursues improvements in survivals of both inriver migrants and transported fish. The interim operation improves the likelihood that the right path will be chosen for a long term option, while minimizing the risk that the wrong path will be followed in the interim.

Analyses conducted by NMFS, including analyses of the species entire life cycle, indicate that the reasonable and prudent actions will contribute to the survival of the listed stocks and to their recovery once major structural modifications are implemented. Species' biological requirements are likely to be met in the migratory corridor only if there are major structural modifications to the FCRPS that result in significant survival improvements. Both surface collectors and natural river drawdown are likely to result in significant survival improvements, as might spillway crest drawdowns if passage issues can be resolved and assumptions about travel time are correct.

In addition, NMFS concludes that the actions described in Section VIII.A represent reasonable and prudent actions. The discussion under each of the major actions in Section VIII.A identifies alternatives examined by NMFS and the considerations that led NMFS to conclude that the alternative chosen was reasonable and prudent. NMFS believes that under the reasonable and prudent alternative, the action agencies will be taking all reasonable measures with respect to the FCRPS to reduce mortalities to listed species.

NMFS concludes that the reasonable and prudent alternative does not jeopardize the continued existence of spring/summer chinook because: 1) the reasonable and prudent alternative is likely to have positive results under either set of hypotheses; 2) the major modifications contemplated in the reasonable and prudent alternative will result in significant survival improvements; 3) the modeling of the reasonable and prudent alternative suggests that stocks are likely to remain above survival levels and modeling of comparable management strategies demonstrates an acceptable probability of recovery once the correct long term pathway has been chosen; 4) the reasonable and prudent alternative provides a prompt but reliable schedule for completing the major modifications required of the system under either of the alternatives; 5) the reasonable and prudent alternative minimizes the risks of catastrophic consequences if the wrong set of hypotheses are embraced; and 6) implementation of this reasonable and prudent alternative will mean that the action agencies are taking all reasonable measures with respect to the FCRPS to reduce listed salmon mortalities.

The reasonable and prudent alternative proposed by NMFS affects all three listed Snake River salmon. As noted, it establishes an interim operation with a decision being made by the year 1999 on a long term operation: surface collectors (which may be associated with either full pools or pools drawn down to spillway crest), or drawdowns to either natural river or spillway crest. NMFS requested the modeling groups to model the interim operation with each of the long term operations. The details of the assumptions used in modeling are described in NMFS (1995d).

NMFS requested modeling of the draft version of the reasonable alternative contained in the January 25 draft biological opinion and received preliminary results of modeling between February 15-22. Final analyses are still in progress, but NMFS must use currently available information to complete the 1995 Opinion in a timely manner. The modeling results NMFS had as of February 22, 1995 represent the best information available to NMFS regarding modeling. Details of the results are included in NMFS (1995d). NMFS also considers relevant the results of modeling of the 1994-98 BIOP scenario, discussed in section IV.B (1994 BIOP), and results of modeling of the state and tribal proposal in the Detailed Fishery Operating Plan (DFOP) described in NMFS (1995d). DFOP scenarios modeled included a spillway crest drawdown (DFOP-1) and a natural river drawdown (DFOP-2).

The reasonable and prudent alternative Options analyzed by the modeling teams are not the same in all details as the final reasonable and prudent alternative adopted by NMFS because changes were made to the alternative after consideration of comments received. Neither of the modeling groups had time to include all model sensitivities, so there is a fairly narrow range of assumptions incorporated in the modeling analysis available. The state and tribal modeling group (STFA) did not have time to model all of the long term scenarios. NMFS used the results of the modeling as it did in analyzing the proposed action -- as a guide to expected population trends under a particular management strategy rather than an absolute indicator of probabilities. Because the modeling was incomplete, even greater caution should be used in interpreting the results.

1. Spring/Summer Chinook

Based on its best professional judgment, NMFS concludes that under the reasonable and prudent alternative, in conjunction with other improvements in the life cycle of the listed stocks, the biological requirements of the spring/summer chinook are likely to be met.

The value of the strategy pursued in the reasonable and prudent alternative is that it improves the likelihood that the right path will be chosen for a long term option, while minimizing the risk that the wrong path will be followed in the interim. For example, in order for natural river drawdown to meet the species' biological requirements, an assumption must be made that transport survival is only 51 percent and there is a strong positive relationship between flow and survival. Conversely, in order for the 1994 BIOP scenario to meet the species' biological requirements, an assumption must be made that transport survival is 54-95 percent and that there is a weak relationship between flow and survival. Because the reasonable and prudent alternative is likely to achieve survival in the near term, it is likely that a five year period for generating better scientific information on the competing hypotheses prior to committing to one or the other strategy will not pose unacceptable risk to the species. NMFS also believes that the time frame to implement the long term options of the reasonable and prudent alternative is a realistic and responsible one.

The reasonable and prudent alternative maximizes the ability to gather information to make a long term decision. It is an adaptive management approach, which includes monitoring and evaluation and adjustment of operations as new information is developed. NMFS therefore concludes that this approach is likely to lead ultimately to an understanding of the combination of management actions necessary to determine which of the long term measures to pursue. This is consistent with NMFS' view that it would not be prudent to rely solely on the results of one set of modeling of one management scenario to reach a conclusion of no jeopardy.

NMFS recognizes that if one set of key assumptions ultimately proves correct, using the best science available, then its decision to retain several options in the interim period will result in some elevated level of mortality as compared with an approach that places complete reliance on the "right" path immediately. Nevertheless, NMFS believes that accepting the marginal increased risk is prudent, particularly given the consequences of pursuing the wrong approach. If transport survival is high, the reasonable and prudent alternative will result in reduced survival during the interim operation because fewer fish are being transported than under the operation proposed by the action agencies. NMFS considers this trade-off acceptable because of the risk that transport survival may be lower than believed and because life cycle analysis indicates that spreading the risk will not result in an unacceptably low likelihood of survival in the short term even if the "high transport survival" hypothesis is correct.

The survival improvements that are anticipated to result from major structural improvements called for in the long term Options of the reasonable and prudent alternative also contribute to the conclusion that this alternative will contribute to the survival and recovery of the listed stocks. Passage improvements at dams, such as surface collectors, can increase fish passage efficiency from current levels of 45-77% to as high as 80%. These passage improvements will result in fewer fish passing through turbines, improving inriver survival significantly, or improving collection efficiency, which will increase the number of fish receiving transportation benefits. Natural river drawdown would completely eliminate mortality associated with both reservoir and dam passage.

Results of life cycle modeling also tend to support a conclusion that the reasonable and prudent alternative is likely to result in the species' biological requirements being met. Both life cycle models indicate that there is a high likelihood, under certain assumptions NMFS considers reasonable, that the survival goals described in NMFS (1995a) will be met if the reasonable and prudent alternative is implemented. In addition, both models' analysis of alternate scenarios proposed by other parties (1994 BIOP and DFOP-2), and which are contemplated by the long term options of the reasonable and prudent alternative, indicate that there is a high likelihood that both the survival and recovery goals will be met.

FLUSH/ELCM modeling of Option 1 indicates that, under certain assumptions considered reasonable by NMFS, at least four of five index stocks have a probability of 70-80% of being at or above the threshold level in 24 or 100 years. Assumptions include a 25% reduction in reservoir mortality due to the predator removal program, a relatively low survival of transported fish, and no depensation at low population levels. This modeling may underestimate survival because the STFA modeling group did not model implementation of surface collectors under this Option. CRiSP/SLCM results are similar to FLUSH/ELCM results for this Option. Under certain assumptions NMFS considers reasonable, at least four of five index stocks have at least a 70% probability of being at or above the threshold level in 24 or 100 years.

Neither FLUSH/ELCM nor CRiSP/SLCM modeling of the scenario similar to the reasonable and prudent alternative indicate that there is a greater than 50% probability that stocks will achieve recovery levels in 48 years. These results do not indicate, however, that there is an unacceptable likelihood of recovery under Option 1. Option 1 of the reasonable and prudent alternative is similar to the 1994 BIOP scenario, which

CRiSP/SLCM predicts to have an acceptable likelihood of achieving the recovery goal. If the operation after implementation of surface collectors involved maximum collection and transportation, the CRiSP/SLCM results would likely show a greater probability of recovery. If the adaptive management approach indicated this was the appropriate strategy to pursue, then beginning in 2003 Option 1 would lead to that operation.

Option 2 modeling results are not as optimistic as Option 1 results. FLUSH/ELCM modeling indicates that, under certain assumptions considered reasonable by NMFS, at least four of five index stocks have a 70% or higher probability of being at or above the threshold level in 100 years, based on assumptions of a 25% reduction in reservoir mortality due to the predator removal program, a relatively low survival of transported fish, and no depensation at low population levels. CRiSP/SLCM results indicate that none of the threshold criteria can be met for four of five index stocks under any of the assumptions modeled by the BPA analytical team. Neither the FLUSH/ELCM nor the CRiSP/SLCM modeling indicates an acceptable probability that stocks will reach recovery levels in 48 years.

Option 3 was not modeled by FLUSH/SLCM due to time limitations. Therefore, only CRiSP/SLCM results were available. CRiSP/SLCM results for Option 3 indicate that none of the threshold or recovery criteria can be met for four of five index stocks under any of the assumptions modeled by the BPA analytical team. In the absence of FLUSH/ELCM modeling of the reasonable and prudent alternative for natural river drawdown, NMFS will assume that some indications can be drawn from the FLUSH/ELCM modeling of the similar model of the DFOP-2 option. FLUSH/ELCM results indicated a high likelihood that four of the five index stocks would remain above the threshold level and a moderate to high likelihood four of the five index stocks would remain above the recovery level under a natural river drawdown scenario. NMFS recognizes that the comparison between Option 3 and DFOP-2 is not perfect because DFOP-2 includes different interim measures and an accelerated schedule for drawdowns. The drawdown schedule most recently proposed by COE of completion by 2004, however, is close to the time proposed in DFOP-2. While a delay in drawdown may delay recovery, it is likely the stocks will stay above survival levels in the near term, regardless of which hypothesis is correct, and therefore likely that recovery may ultimately be achieved. NMFS concludes it is reasonable to consider this modeling of DFOP-2 as indicative of a positive trend toward recovery under a natural river drawdown if the hypotheses underlying the FLUSH model are correct.

In addition to the above modeling analyses of the three long term options, BPA submitted model runs for the aggregate spring chinook component of the Snake River spring/summer chinook ESU.

These runs are described in NMFS 1995a. In general, CRiSP/SLCM aggregate model results for the three options comprising the 1995 BIOP option were more optimistic with respect to long term survival and recovery than results based on the five index stocks. While the 24-year threshold could not be achieved at 70% probability under any assumptions for any of the three long-term options, the 100-year threshold was met or exceeded at >80% probability under all assumptions for Option 1 and under some assumptions for Option 3. Recovery goals at 48 years were met under all assumptions for Option 1 and under some assumptions for Option 3.

In summary, under certain assumptions considered reasonable by NMFS, both the FLUSH/ELCM and the CRiSP/SLCM models show a high likelihood that four of the five index stocks will stay above the survival threshold under the interim action and at least one of the long term options (or surrogates of those options) set out in the reasonable and prudent alternative. Some of these assumptions must be viewed with caution, such as the assumption in CRiSP/SLCM of no depensation. (Section IV contains a discussion of the treatment of the depensation function in CRiSP/SLCM.) Nevertheless, both sets of models show a positive trend in spring/summer chinook populations under the interim operations and at least one of the long term options over the next 24 years. The likelihood that stocks will achieve recovery levels in 48 years is less clear from the modeling based on the actions in the reasonable and prudent alternative as modeled by the modeling teams. Modeling of other scenarios that roughly approximate the reasonable and prudent alternative reported in NMFS (1995d) and discussed above creates greater optimism about the likelihood of recovery over the long term when the right course is ultimately pursued.

Overall, NMFS finds these results encouraging, when considered in conjunction with modeling of the 1994 BIOP and DFOP-2. Both models, each using opposing sets of assumptions, show an increasing trend in the short term, with a high likelihood under some assumptions that survival requirements will be met. The reasonable and prudent alternative also minimizes the risk that the stocks will decline in the interim because the wrong strategy was followed.

NMFS therefore concludes that the reasonable and prudent alternative does not jeopardize the continued existence of spring/summer chinook because: 1) the reasonable and prudent alternative is likely to have positive results under either set of hypotheses; 2) the major modifications contemplated in the reasonable and prudent alternative will result in significant survival improvements; 3) the modeling of the reasonable and prudent alternative suggests that stocks are likely to remain above survival levels and modeling of comparable management strategies demonstrates an acceptable probability of recovery once the correct long term pathway has been chosen; 4) the reasonable and prudent alternative provides a prompt but reliable schedule for completing the major modifications required of the system under either of the alternatives; 5) the reasonable and prudent alternative minimizes the risks of catastrophic consequence if the wrong set of hypotheses are embraced; and 6) implementation of this reasonable and prudent alternative will mean that the action agencies are taking all reasonable measures with respect to the FCRPS to reduce listed salmon mortalities.

2. Snake River Fall Chinook Salmon

Qualitative considerations regarding the likelihood of survival and recovery for fall chinook are the same as those stated for spring/summer chinook. Modeling of fall chinook populations is even more optimistic than that for spring/summer chinook. General information regarding methods of modeling the reasonable and prudent alternative is identical to that described for Snake River spring/summer chinook salmon. Details are included in NMFS (1995d). For Option 1, FLUSH/ELCM modeling indicates that, under certain assumptions considered reasonable by NMFS, fall chinook salmon have a probability of at least 70% of being at or above the threshold level in 24 or 100 years. Under a combination of optimistic but plausible assumptions (based on the Recovery Plan), there is a 50-70% probability of being above the recovery level in 48 years. CRiSP/SLCM results indicate that, under certain assumptions, an acceptable probability can be achieved for both short-term and long-term threshold and recovery goals.

Under the Option 2 scenario, FLUSH/ELCM modeling indicates that, under all assumptions modeled, fall chinook salmon have at least a 90% probability of being at or above the threshold level in 24 or 100 years. Under no assumptions is there at least a 50% probability of being above the recovery level in 48 years. CRiSP/SLCM results indicate that none of the threshold or recovery criteria can be met for fall chinook salmon under any of the assumptions modeled by the BPA analytical team.

As noted for spring/summer chinook, STFA modelers did not have time to model the natural river drawdown Option 3 of the 1995 BIOP. For reasons stated in the discussion of spring/summer chinook, NMFS considers the FLUSH/ELCM modeling of the DFOP-2 scenario to be indicative of the positive population trend likely to result from this Option. Conversely, CRiSP/SLCM results indicate that none of the threshold or recovery criteria can be met for Snake river fall chinook salmon under any of the assumptions modeled by the BPA analytical team.

Both sets of models demonstrate an increasing trend for fall chinook under the interim operation. Both models have a high likelihood of meeting survival goals. For each of the models, at least one long term scenario is likely to lead to recovery. Modeling results for fall chinook are generally even more optimistic than those for spring/summer chinook. In addition, the reasonable and prudent alternative appears preferable at this time for fall chinook because of the likelihood that the wrong choice could have negative consequences. Based on the same analysis applied to spring/summer chinook, NMFS concludes that the reasonable and prudent alternative avoids jeopardy to fall chinook.

3. Sockeye

There is no modeling for sockeye salmon. Because of the critically low population levels, there is a limited ability for improvements in the hydropower system to provide the necessary improvements to ensure survival and recovery of the species. The NMFS expects that survival improvements for listed sockeye salmon will be of the same magnitude as those for listed spring/summer chinook. Given that the captive broodstock program represents the best alternative for survival and recovery of sockeye, and that improvements in the hydropower system are expected to be substantial, NMFS concludes that the reasonable and prudent alternative does not reduce appreciably the likelihood of survival and recovery of listed sockeye salmon.

IX. REINITIATION OF CONSULTATION

Consultation must be reinitiated if: the amount or extent of taking specified in the Incidental Take Statement is exceeded, or is expected to be exceeded; new information reveals effects of the action may affect listed species in a way not previously considered; the action is modified in a way that causes an effect on listed species that was not previously considered; or, a new species is listed or critical habitat is designated that may be affected by the action (50 CFR 402.16).

These general conditions apply as well to prospective agreements, plans and contracts ("prospective agreements") that the action agencies use to plan for operation of or to actually operate the FCRPS and to coordinate operations with Canada and regional utilities. Examples include implementation of the Columbia River Treaty (Treaty) between the United States and Canada, such as by the adoption of assured operating plans and detailed operating plans; arrangements with Canada for Non-Treaty storage; and renewing and revising the Pacific Northwest Coordination Agreement.

To the extent that the prospective agreements are used to achieve operations that are in accordance with this biological opinion, including its reasonable and prudent alternative, reasonable and prudent measures, and terms and conditions, the effects of those prospective agreements on Snake River salmon have been considered in this biological opinion. To the extent that proposed agreements have effects on FCRPS operations that affect listed fish in ways not considered in this biological opinion, or have provisions that go beyond implementing the operations specified in the opinion, those proposed actions may require separate consultation or reinitiation of this consultation.

X. CONSERVATION RECOMMENDATIONS

Conservation recommendations are discretionary measures suggested to minimize or avoid adverse effects of a proposed action on listed species, to minimize or avoid adverse modification of critical habitat, to develop additional information, or to assist the Federal agencies in complying with their obligations under section 7(a)(1) of the ESA. The NMFS believes the following conservation recommendations are consistent with these obligations, and therefore should be implemented by the operating agencies:

1. The BPA and COE should evaluate previous research and, if necessary, continue study and refinement of adult spill patterns. The COE and Columbia River Basin fishery agencies and tribes should determine the effect of low-level, mid, and high spill levels on adult passage. Establishment of optimum spill patterns, based on adult passage studies, is likely to improve passage success for chinook and sockeye salmon, as well as other anadromous species. Studies by Mendel et al. (1993) and Bjornn et al. (1993) indicated that dam passage delays for chinook salmon, sockeye salmon, and other anadromous species at Columbia and Snake River projects are substantial. More recent research (Bjornn et al. 1994) indicates delays of less significant duration, but improvements may still be attainable. Upstream passage has been identified as a significant problem requiring attention (SRSRT 1994). Spilling to increase attractant flows may reduce passage delays, increase the use of entrances near spillways, or both (Bjornn and Peery 1992, Dauble and Mueller 1993).

Spill for adult passage was implemented at several projects in 1994. The Idaho Cooperative Fish and Wildlife Research Unit conducted studies to evaluate passage of adult chinook salmon and steelhead at the lower Snake River dams in 1994. If past research results are inconclusive, evaluate further by continuing adult passage research studies.

2. The COE, BPA, and BOR should further investigate adult fish passage, with an emphasis in the lower Columbia River projects,

including: (1) "baseline" survival rates for adult salmonids migrating upriver through free-flowing reaches of the Columbia and Snake Rivers; (2) mortality and interdam losses; (3) entrance to fishways during periods of medium and high spill levels; (4) investigation and improvement of adult fishway hydraulics; (5) evaluation of the magnitude of adult passage through navigation locks, and (6) evaluation of effectiveness of adult passage orifices.

One possible method of achieving improved passage is to install additional fish ladders at projects with a ladder on only one shore (Lower Granite and Little Goose Dams). Other Snake and Columbia River projects with fish ladders on both shores have fish passing through both north and south ladders. Additional routes of passage at Lower Granite and Little Goose Dams may increase passage success of chinook and sockeye salmon, as well as other anadromous species, particularly during periods of high spills. An additional fishway would also allow ladder passage while inspecting or maintaining the other fishway. Another possible method of improving adult passage is to extend collection channels at Little Goose and Lower Granite Dam north shore entrances. Inefficient north shore entrances at these projects result in high fallout rates (Turner et al. 1983). An improvement in the fallout problem is needed to reduce passage delay of chinook and sockeye salmon, as well as other anadromous species. High spills adversely impact entrance attraction flows from north shore entrances due to their proximity to the spill bays. More spill for juvenile fish passage in the future may exacerbate this problem. Channel extensions with entrance relocation may address this concern.

Insufficient entrance depths and insufficient entrance attraction velocity are factors that negatively affect adult fish passage (Bell 1991). The MOP operation of the next project downstream impacts the ability to meet entrance criteria. Maintaining fishways within optimum criteria for passage reduces migration delays for chinook and sockeye salmon, as well as other anadromous species.

Interdam losses of migrating adult chinook and sockeye salmon, as well as other anadromous species, are puzzling and have been the subject of research investigations such as those by Mendel et al. (1993) and Bjornn et al. (1993). Fish are known to pass dams by entering the navigation locks, but the magnitude of this behavior is not completely understood (Bjornn and Peery 1992).

The COE and Columbia River Basin fishery agencies and tribes should review adult passage study data and ineffective adult passage orifices should be identified. Orifice entrances that are ineffective in passing salmon should be closed. If adult passage studies provide conclusive information, flows from ineffective entrances should be shifted to main entrances to improve passage success. Some structural modifications may be needed to implement such shifting of flow.

The effects of (1) closing adult collection channels; and (2) closing some or most of the entrances, particularly the floating orifices, to improve flow conditions between the fishway entrances and the base of the fish ladders should be evaluated. Mid-Columbia River research conducted in 1993 showed that most fish passage delay occurred in the collection channels (Stuehrenberg et al. 1994).

Evaluation and recommendations as a result of reviewing lower Snake River adult migration studies should be completed by February 1996. If evaluation of past adult passage research does not provide conclusive information, lower Columbia River adult migration studies, scheduled to commence in 1996, should be incorporated into the evaluation as the annual reports become available.

3. The COE should continue to implement and refine modifications established under the PIES program and continue evaluation of the John Day Dam ladder exit sections during the lower Columbia River adult migration study. The exit sections of both ladders cause adult delay and jumping. The reason for this problem is not fully understood and requires further study.

4. The COE should continue monitoring the magnitude of fall chinook salmon spawning activity in the mainstem Snake River below Lower Granite Dam through 1998. Surveys in the fall of 1993 and 1994 identified fall chinook salmon redds in the tailrace areas of Lower Granite and Little Goose Dams (D. Kenney, fishery biologist, COE, December 9, 1994, pers. comm.). Mainstem spawning may affect project operations and construction activities in the tailrace areas of Snake River dams.

5. The COE, in coordination with BPA, should develop a program to comprehensively study engineering and biological aspects of juvenile fish passage through turbines, develop biologically based turbine design criteria, and evaluate how well various prototype designs and modifications improve juvenile fish survival through Kaplan turbines.

6. The COE and BPA should develop and implement a regional research facility. The COE should complete a feasibility study to assess existing capabilities to meet projected research needs identified through the System Configuration Study, the FPDEP Program, and other regional forums by August 1995. Pending results, a regional research facility should be in place no later than 1998. Many SCS projects to improve fish passage involve development and evaluation of conceptual designs that are on the

leading edge of passage technology. Such studies could logically include biological/hydraulic studies for development of various components of passage systems (i.e. fish collection systems, improved tag detectors, improved counting facilities, etc.). Biological and engineering studies may require substantial changes to existing facilities which would require evaluation. As such, there is potential for conflict with current operations and impacts to listed species. A dedicated regional research facility has potential to avoid making major modifications to existing facilities and/or operations while still providing necessary information for decision makers.

XI. REFERENCES

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XII. INCIDENTAL TAKE STATEMENT

Section 9 and regulations implementing Section 4 of the ESA prohibit any taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct) of listed species without a specific permit or exemption. When a proposed Federal action is found to be consistent with Section 7(a)(2) of the ESA (i.e., the action is found not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat) and that action may incidentally take individuals of listed species, NMFS will issue an incidental take statement specifying the impact of any incidental taking of endangered or threatened species.

The incidental take statement also provides reasonable and prudent measures that are necessary to minimize impacts, and sets forth terms and conditions with which the action agency must comply in order to implement the reasonable and prudent measures. Incidental takings resulting from the agency action, including incidental takings caused by activities authorized by the agency, are exempted from the taking prohibition by section 7(o) of the ESA, but only if those takings are in compliance with the specified terms and conditions.

The reasonable and prudent alternative to the proposed action described in section VIII of the biological opinion has been found to be consistent with Section 7(a)(2) of the ESA. An incidental take of listed Snake River salmon is expected to occur as a result of the reasonable and prudent alternative. In the absence of exact numbers of listed Snake River salmon expected to be taken, the approximate mortality rates for listed salmon resulting from passage through the FCRPS that were identified in section VIII.B provide the best available estimate of incidental take levels. However, these quantitative estimates should be viewed with considerable caution for reasons discussed in section IV.B.7 of the biological opinion and in NMFS (1995d).

If measures described in the reasonable and prudent alternative are implemented, expected mortalities of listed salmon passing through the FCRPS should not exceed: 24 to 86% juvenile and 11.4% adult Snake River sockeye salmon, 24 to 86% juvenile and 21% adult Snake River spring/summer chinook salmon, and 62 to 100% juvenile and 39% adult Snake River spring/summer chinook salmon. Quantitative estimates for juvenile passage mortality are based on simulation model analyses and are subject to caveat regarding assumptions, as described in section IV.A.7, NMFS (1995a), and NMFS (1995d). The broad range of estimates represents a combination of various model assumptions, a range of expected environmental conditions, and three potential long-term actions associated with the reasonable and prudent alternative.

1. The COE and BOR shall incorporate the flow objectives and other relevant provisions of this plan into Pacific Northwest Coordination Agreement planning.

For improved efficiency, the hydrosystem is operated as nearly as possible as one system under the Pacific Northwest Coordination Agreement (PNCA). Incorporation of minimum required flows for salmon into PNCA firm power planning will improve the ability to provide these flows each year because of optimized year-round system operations.

2. The COE shall evaluate and improve juvenile spill patterns at John Day Dam by summer 1996. Spill patterns influence juvenile mortality at dams.

Establishment of optimum juvenile spill patterns is anticipated to reduce mortality for chinook and sockeye salmon, as well as other anadromous species, by reducing exposure to predators below spillways. All other Portland District, COE, hydroelectric projects have been evaluated for juvenile spill patterns.

3. The COE shall provide independent station service for both powerhouses at Bonneville Dam by late-1997/early 1998, pending the results of the Project Power Distribution Master Plan.

Passage survival tests at Bonneville Dam indicate that tailrace predation may be substantial (Ledgerwood et al. 1990). Northern squawfish are major predators of juvenile salmonids in the Columbia River Basin. Results of swimming performance tests indicate that high water velocities exclude or reduce predation by northern squawfish due to their inability to hold position (Mesa and Olson 1993). Providing station service capability at each powerhouse would enable project operators to concentrate powerhouse flow at either powerhouse to maximize tailrace flow and minimize predation in the tailrace.

4. The BPA shall provide for sampling of juvenile fish at all dams with sampling facilities.

Monitoring for fish condition is necessary in order to detect and rectify juvenile fish passage facility problems that can descale, injure or kill fish. Sampling capability is also required for approved monitoring programs and research.

5. The COE shall operate McNary Dam according to special operating criteria to mitigate adverse warm water conditions that periodically occur in the summer. The COE, in close coordination with NMFS and the States and Tribes shall:

a. Define parameters to be used to determine when fish cannot cope with additional stress of powerhouse collection and holding/loading facility.
b. Continue the collection of thermal profile data in the summer, including use of 24-hour recording thermometers to measure diel temperature changes. Intensify water temperature monitoring and be prepared to implement emergency measures when gatewell temperatures in operating units approach 68 $^{\circ}$F.
c. Abrupt changes in powerhouse operations (i.e. unit start up /stoppages) should be avoided during critical warm water temperature periods.
d. Transport collected fish every day when critical warm water temperatures exist in juvenile holding facilities.
e. Evaluate whether northern powerhouse loading should be continued.
f. Provide additional biological staff during swing/graveyard shifts if needed to enable a quick response when there is potential for a thermal stress problem.
g. When facility mortality exceeds six percent of the daily collection for three consecutive days, and/or mortality exceeds 10,000 fish in a 24-hour period, the COE shall consult with NMFS and the States/Tribes to determine whether operations should be modified. Revised operations may include terminating powerhouse collection and initiating passage of juvenile fish via the spillway to the maximum possible extent.
h. Evaluate whether an emergency water supply source for the juvenile holding/loading facility is needed. Provide recommendations to NMFS by the end of 1995.
i. Reevaluate the design of the primary dewatering screen cleaning system and implement necessary modifications to improve performance as soon as possible.
j. McNary Project operators, North Pacific Division-RCC, and BPA shall coordinate planning relative to capability for promptly shifting load and implementing spillway passage when thermal-related mortalities trigger the need for emergency project operations to protect juvenile migrants.
k. Provide permanent shading over raceways to reduce solar radiation. Complete construction by the end of 1995.
l. After the spring migration, but before the summer migration period, inspect and clean (by pressure washing) screens at the primary dewatering structure.
m. Evaluate methods for inspecting primary dewatering screens during the migration season without having to dewater the facility. Provide recommendations to NMFS by the end of 1995.

6. The COE shall improve hydraulic conditions in both Bonneville Dam powerhouse juvenile fish collection channels by 2000.

Existing dewatering screens do not meet current NMFS screening criteria and excessive fish delay and exhaustion has been documented at the second powerhouse (Krcma et al. 1984; Dawley et al. 1993).

7. The COE should evaluate all modifications to fish bypass and collection facilities to assure that they work as designed and cause minimal adverse effects to fish passing through them. Post-construction evaluations are needed to ensure that flows are adequate, construction debris has been removed, and surfaces are smooth and free of any obstructions that could harm fish.

8. The COE shall evaluate the relative benefits of establishing dispersed release sites by short-haul barging and/or constructing multiple flume outlets at dams. An increase in predator populations as a result of dam-created artificial habitat and concentrating prey is a factor for the decline of each listed Snake River salmon species (NMFS 1991a,b,c). Ideal foraging environments have been created below mainstem dams. Single-point outfalls allow predator concentrations to form, thereby increasing smolt mortality (Mesa and Olson 1993; Ledgerwood et al. 1990). Dispersed release sites may reduce the effect of predator concentrations on juvenile mortality.

9. The COE shall conduct studies to identify (a) Caspian tern predation of juvenile salmonids, and (b) methods to discourage tern nesting. The Caspian tern, *Sterna caspia*, population in the lower Columbia River has increased significantly. The tern colony at Rice Island (an island created by dredged material disposal by the COE) is the largest on the west coast of North America (Gill and Mewaldt 1983). The NMFS believes that this colony has the potential to consume large numbers of smolts each year.

10. The COE shall provide hydroacoustic monitoring of juvenile salmon passage through the powerhouse, spillway, and sluiceways at Ice Harbor Dam during the migration in 1995. Similar hydroacoustic monitoring shall occur at The Dalles Dam in 1996. Planning for the 1996 passage season should occur as soon as possible to ensure equipment is available, and that needs can be met.

The intent of this task is to investigate the passage behavior of juvenile salmon migrants, both in passage location and timing. Secondly, the purpose is to estimate spill effectiveness under differing project operations to determine if and how the effectiveness of spill in passing migrants can be enhanced.

11. Beginning in 1995, BPA will evaluate the affect of power peaking operations on juvenile and adult salmon passage and on the river ecology downstream of Bonneville Dam and on the Hanford

Reach, downstream of Priest Rapids Dam. Contingent on the results of these evaluations, BPA will develop a plan to decrease power peaking operations from mid-March through mid-December on the lower Snake and Columbia Rivers.

Passing more water through the powerhouse when the demand for power is high and reducing powerhouse flow when power demands are low is termed power peaking. Power peaking causes daily fluctuations in discharges, which result in substantial variation in adult passage success (Bjornn and Peery 1992, Dauble and Mueller 1993). A greater operating range in reservoir elevation allows increased power peaking, i.e., increased powerhouse flows during the day and lower flows during the night. Zero-flow for 4-5 hours at night has not been shown to delay adults, adult salmon generally not passing dams at night. However, increased powerhouse discharge has been shown in a number of studies to increase delay (13-83% higher passage with lower powerhouse discharge; 40% reduction in powerhouse discharge doubled net passage) and may increase mortality of adult salmon. Delay of juvenile salmon in the forebay of a powerhouse also occurs with decreases in discharge, particularly at night when a much higher percentage of juveniles is passing (nighttime spill would alleviate this effect).

12. The COE shall investigate and remedy water pollution problems within fishways and gatewells that may contribute to fish mortality. The EPA, in coordination with the state water quality agencies, will provide oversight and recommendations for remedies. Fish avoid or are affected by some chemicals and odors (Bell 1991, Dauble and Mueller 1993). Reducing river pollutants in general, and particularly at projects where passage through a fishway is necessary, may increase adult chinook and sockeye salmon passage success and reduce mortality, as well as that of other anadromous species.

The COE’s PIES program has identified improvement of water quality in the fishways of Bonneville, The Dalles, and John Day Dams as one of its actions. Similar efforts should be directed at all Columbia and Snake River projects.

13. The COE shall continue 24-hour counting at Ice Harbor and Lower Granite Dams, and counting during non-manual counting periods at Bonneville Dam (particularly at night) to bolster current knowledge of adult migration and dam passage. Interdam losses of migrating adult salmon are puzzling and have been the subject of research investigations such as those by Mendel et al. (1993) and Bjornn et al. (1993). More precise counting methods are necessary to expand the knowledge of chinook and sockeye salmon migration characteristics and problems. Information on adult migration characteristics for other anadromous species will also be obtained. The FPP should be revised to reflect full time

counting implementation at the aforementioned dams by March 15, 1995.

The COE shall prepare a report on the current adult fish counting program which details counting procedures, suitability of alternative counting techniques in different counting situations, and recommendations for improvement to the existing counting program. This report should be reviewed by the Fish Facilities Operations and Maintenance Subcommittee.

14. The COE, BPA, and NMFS shall complete the design and development of adult fish PIT-tag detector systems in adult fish passage facilities at mainstem dams immediately, followed by installation with no adverse effect to adult passage. Adult PIT-tag detectors will provide valuable information on adult chinook and sockeye salmon returns and interdam losses, as well as for other PIT-tagged anadromous species.

15. The COE shall procure spare parts for all critical components of adult fishway facilities. On-site spare parts reduce down time and reduce adult chinook and sockeye salmon passage delay, as well as that of other anadromous species.

The COE’s PIES program has identified procuring fish pump spare parts at John Day Dam as one of its actions. Procurement of critical components of adult fishways at other projects should be similarly prioritized.

16. The COE shall develop emergency auxiliary water supplies for all adult fishways where determined, in coordination with NMFS, to be necessary. Emergency supplies are needed to maintain fishways within optimum criteria for passage in the event of turbine or pump failure. Maintaining optimum criteria will improve dam passage success for chinook salmon, sockeye salmon, and other anadromous species. An engineering study is needed to evaluate design options for Columbia and Snake River dams. The study of lower Columbia project needs should be completed by May 1995. Evaluations of those needs can be programmed shortly thereafter, and implemented as determined through the appropriate processes. Evaluation of emergency auxiliary water supply capabilities at the lower Snake projects should be completed by March 1996. A schedule for completing design and installation, where needed, should be completed by November 1996.

The COE shall install emergency auxiliary attraction water system at The Dalles Dam. Adult attraction flows at The Dalles Dam are provided by two fish turbine units which power pumps used to furnish tailrace water for auxiliary attraction flow. These units have been upgraded to improve reliability under the PIES program. However, in the event of equipment failure, there is a substantial risk of blocked passage for adult chinook and sockeye salmon, as well as other anadromous species. Installation of an emergency auxiliary attraction flow system would address this potential problem and should be pursued. Design of an emergency auxiliary attraction flow system should begin immediately, with installation as soon as possible. At this time it is unknown whether a conventional screened juvenile bypass system or surface collection bypass system will be constructed at The Dalles Dam. In either case, the design of the new facility should consider having capability for routing excess water to the east adult fishway as an emergency auxiliary attraction water supply source.

17. The COE shall monitor river water temperatures and implement, when possible, temperature control measures in the lower Snake River, such as releasing cool water from both Dworshak Dam and the Hells Canyon complex (Hells Canyon, Oxbow and Brownlee dams) during August and September. High water temperatures negatively affect the life history of salmonids, including growth, disease resistance, migration, and spawning. Although higher temperatures are frequently encountered during migrations (depending on species and location), maximum optimum temperatures for chinook and sockeye salmon are approximately 58°F (Bell 1991). Measures to decrease water temperatures may reduce stress and contribute to greater passage and spawning success for chinook salmon, sockeye salmon, and other anadromous species.

The COE controls the operations of Dworshak Dam, and the Idaho Power Company controls the operations of the Hells Canyon complex. The Biological Opinion on 1994-1998 Operation of the FCRPS specifies flows from Dworshak that are to be used to decrease fish mortality. Federal Energy Regulatory Commission licenses for projects that affect listed species, such as the Hells Canyon complex, should be subject to consultation so that the necessary fishery requirements to benefit listed species are included.

Evaluate by 1) upgrading the COLTEMP4 water temperature prediction model using the data and knowledge gained from all previous water temperature control operations and monitoring; 2) adding to the existing water temperature data monitoring network provisions to collect meteorological and hydrological data that will identify the effect of tributary watershed management and resulting inflow temperatures on mainstem Snake River water temperatures; 3) adding additional water temperature and water velocity measurements in the lower Snake River, and 4) analyzing ladder counts.

The COE and CRITFC should modify the COLTEMP4 model. The Columbia River Basin fishery agencies and tribes should analyze ladder counts and make recommendations for benefitting fish.

Temperature control measures should be implemented, if necessary, by July 1995.

18. The COE shall provide for water temperature control in fish ladders. Elevated water temperatures negatively affect upstream migration and contribute to the potential for infectious disease (Dauble and Mueller 1993). Summer water temperatures in the Snake and Columbia Rivers often exceed 70°F. Water temperatures in ladders can be even higher than ambient river temperatures. Ladder water temperatures should be similar to or slightly less than tailwater temperatures during summer months. Shading, installation of sprinklers, and pumping cooler water from the depths of forebays into ladders are possible methods to reduce water temperatures in ladders and improve passage success of chinook and sockeye salmon, as well as other anadromous species. The efficacy of one or more of these measures should be investigated in 1995, a prototype (or prototypes) should be tested in 1996/97 (depending on the measures selected), and installation of the preferred alternative(s) should be completed by March 1997/98.